PANEL2050 Regional Trainings
ESTONIA

Training series: How to transition towards sustainable energy?
Koolitustesari: Kuidas jõuda keskkonda säästvama energeetikani?

Trainings' table of contents / *Koolituste sisukord*

1. Innovation in renewable energy / *Innovatsioon taastuvenergeetikas* (19. november 2017)
2. Financing renewable energy projects / *Taastuvenergia projektide rahastamine* (23. november 2017)
3. EU financing mechanisms for sustainable energy projects / *Säästva energeetika rahastamine EL vahenditest* (30. november 2017)
4. Project writing for local governments / *Projektikirjutamine kohalikes omavalitsustes* (8. detsember 2017)
5. Biomethane as transport fuel / *Biometaan transpordikütusena* (24. jaanuar 2018)
6. Planning energy management, creating sustainable energy roadmaps / *Energiamajanduse planeerimine, säästva energeetika tegevuskavade koostamine* (1. märts 2018)

Trainings / Koolitused

1. Innovation in renewable energy / Innovatsioon taastuvenergeetikas

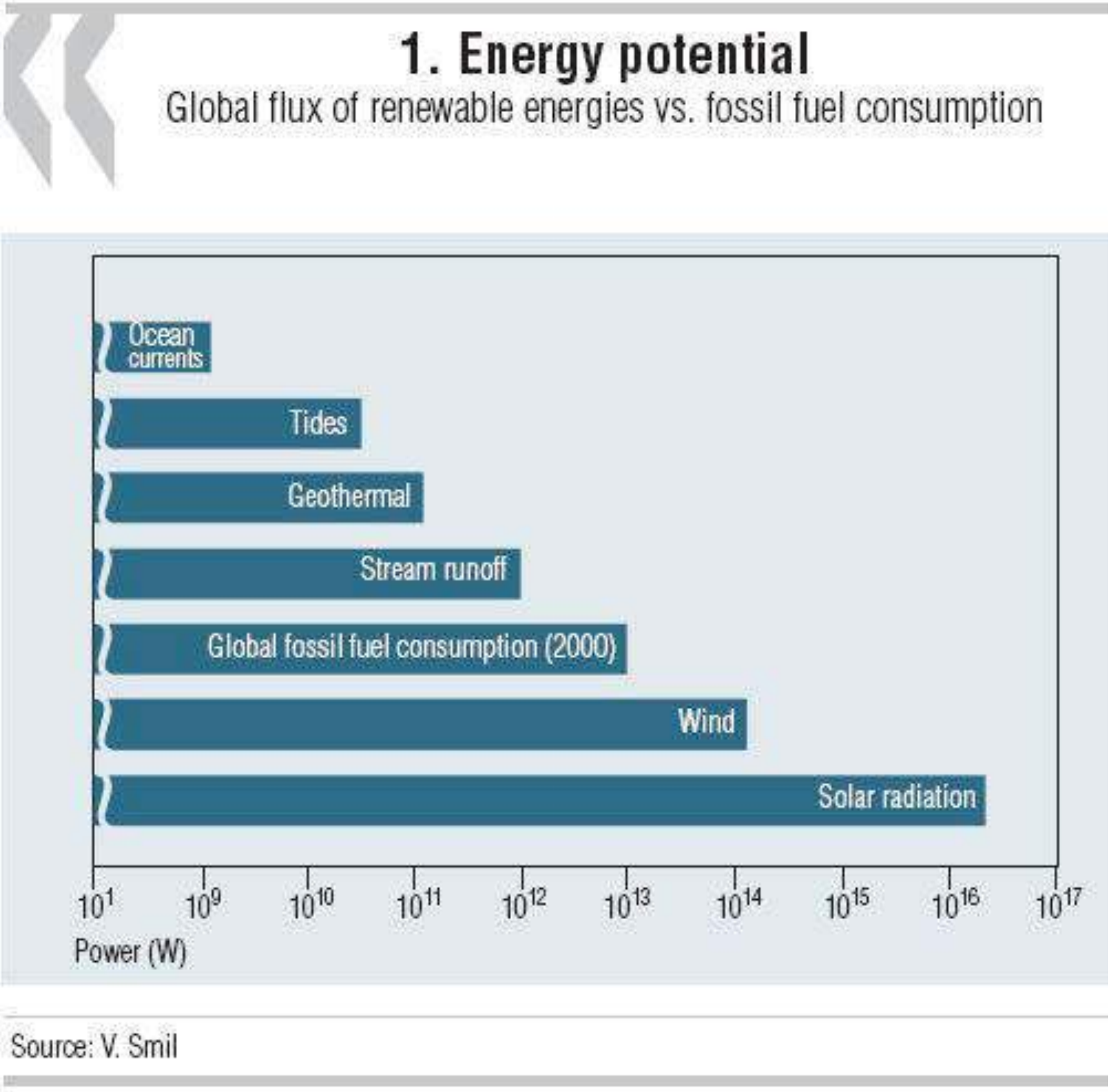
- Innovation in renewable energy. Solutions and challenges / *Innovatsioon taastuvenergeetikas. Lahendused ja väljakutsed*. Enn Lust (Tartu Ülikool)
- International Energy Agency as an engine for energy innovation / *Rahvusvaheline Energiaagentuur kui energiainnovatsiooni mootor*. Peter Gornischeff (MKM esindaja IEA ja OECD juures)
- Energy sector and R&D financing / *Energeetika T&A&I rahastamine.* Maria Habicht (ETAG)
- Directions in solar energy sector / *Päikeseenergia sektori suundumused*. Andres Meesak (Eesti Päikeseenergia Assotsiatsioon)
- Road that produces electricity / *Elektrit tootev tee*. Malle Krunks (TTÜ)
- Innovation in wind energy / *Innovatsioon tuuleenergeetikas*. Tuuliki Kasonen (Eesti Tuuleenergia Assotsiatsioon)
- Development of small wind mills in Estonia and global scale / *Väiketuulikute areng Eestis ja maailmas*. Sergei Melentjev (Tuge Energia)
- Overview of efficient fuel bio-additives / *Efektiivsetest bio-kütuselisanditest*. Raul Raudsepp (TLÜ, NordBioChem)
- Developments in hydrogen energy / *Arengutest vesinikuenergeetikas*. Enn Lust (Tartu Ülikool)
- Perspectives for biomethane / *Biometaani tulevikuväljavaated*. Ahto Oja (Eesti biogaasi assotsiatsioon)
- Innovation in district heating / *Innovatsioon kaugküttes*. Priit Koit (Utilitas AS)
- Tartu district cooling / *Tartu kaugjahutus*. Margo Külaots (Fortum Tartu)
- Estonia as a pilot country for digital energy / *Eesti digitaalse energia pilootriigina*. Georg Rute (Elering)

Innovatsioon taastuvenergeetikas. Lahendused ja väljakutsed

Enn Lust
enn.lust@ut.ee

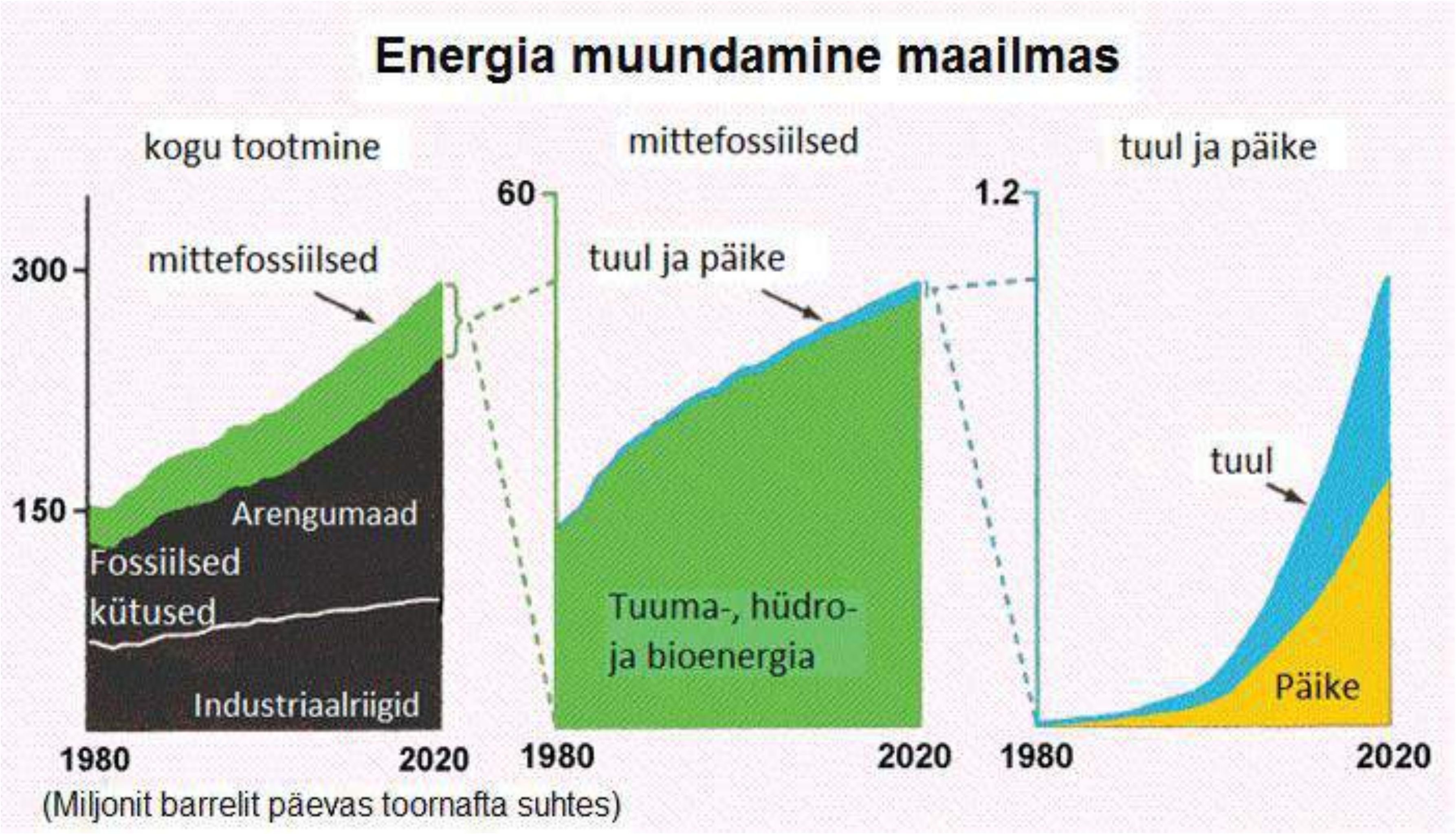
Tartu Ülikool
Keemia Instituut
Füüsikalise keemia ja Rakenduselektrokeemia õppetoolid

Ettekanne: TEUK XIX (2.11.2017)

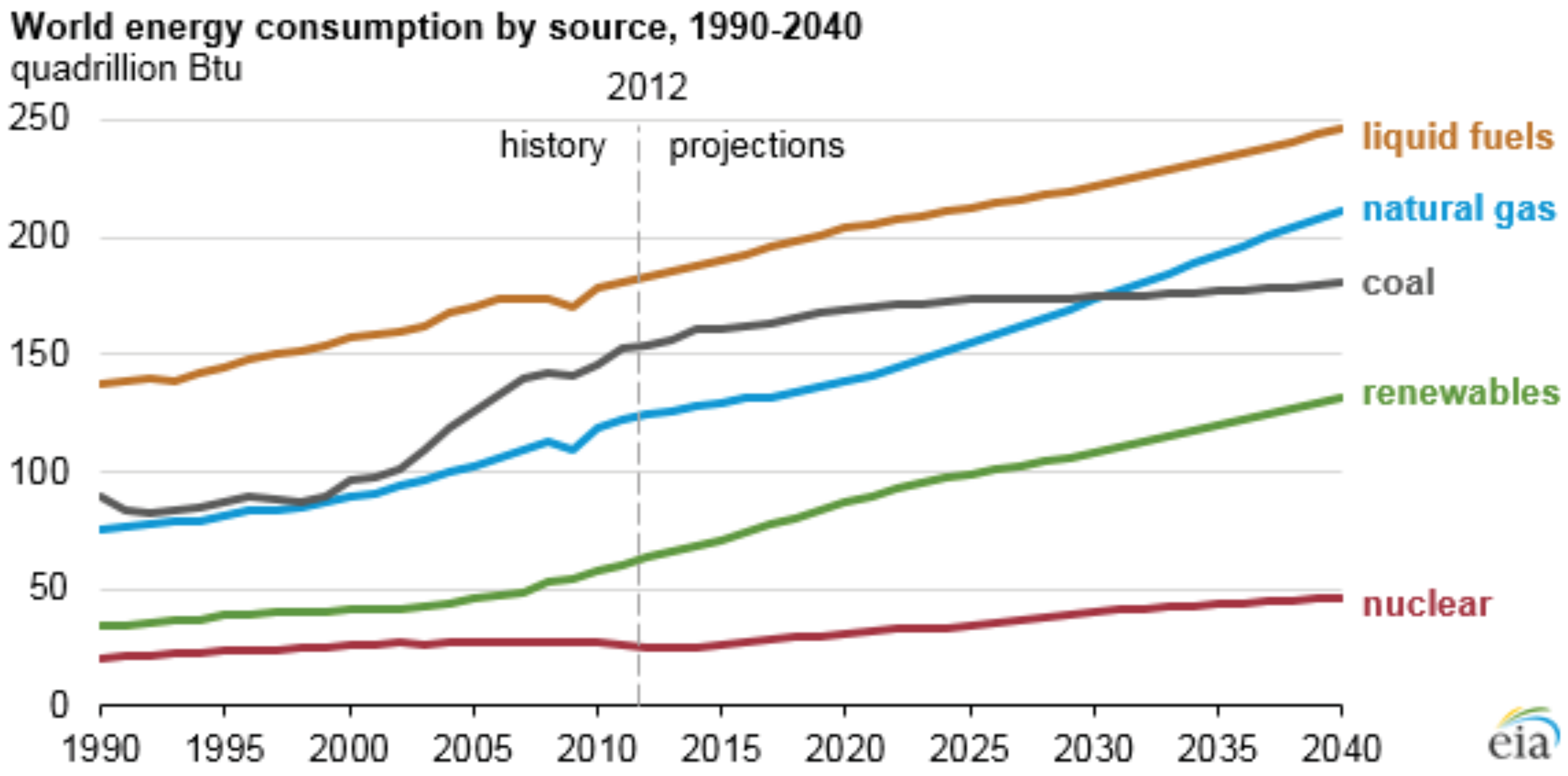


http://www.oecdobserver.org/images/2081.photo.jpg

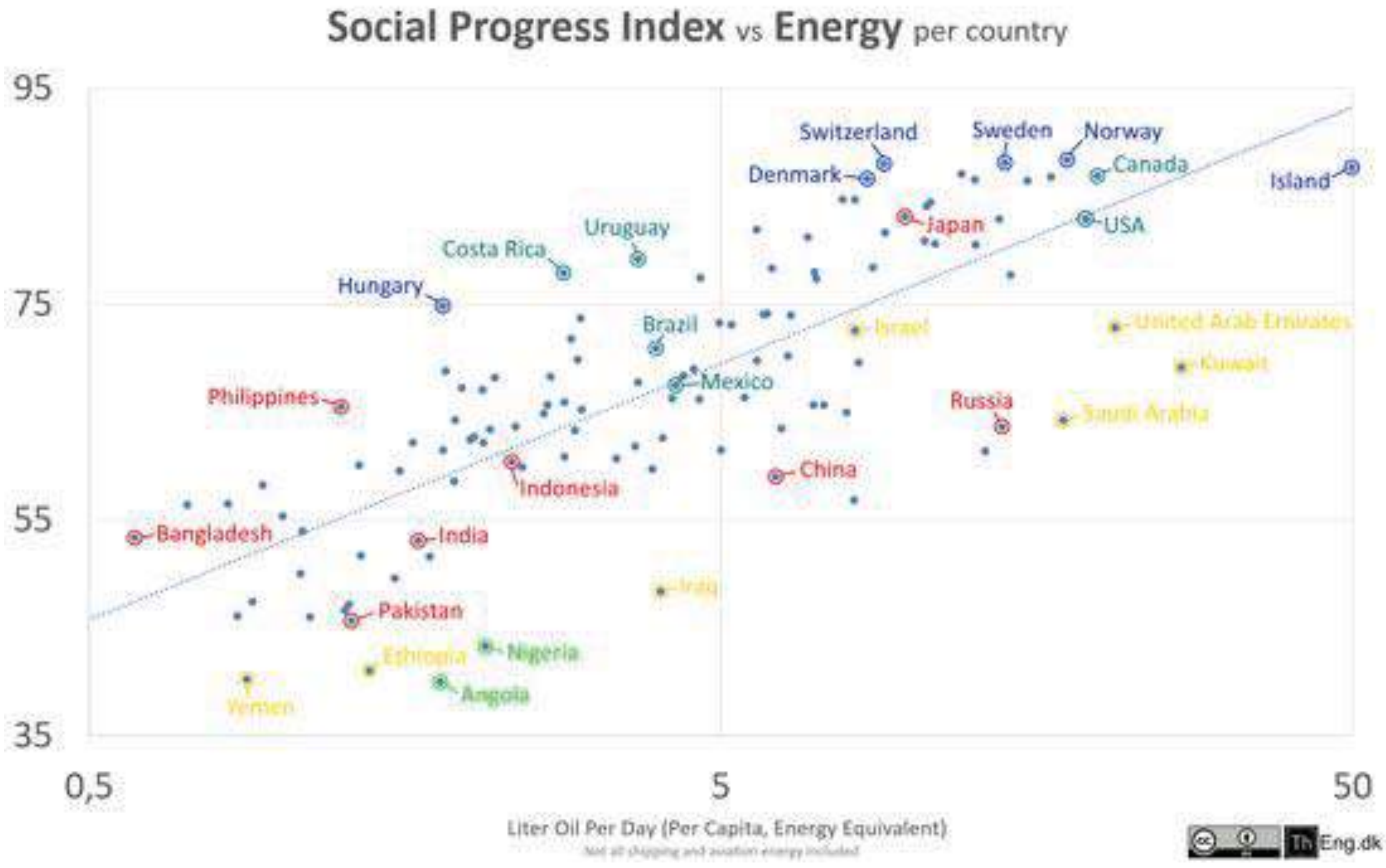
Energia tootmise kasv maailmas ja erinevate energiaallikate osakaal



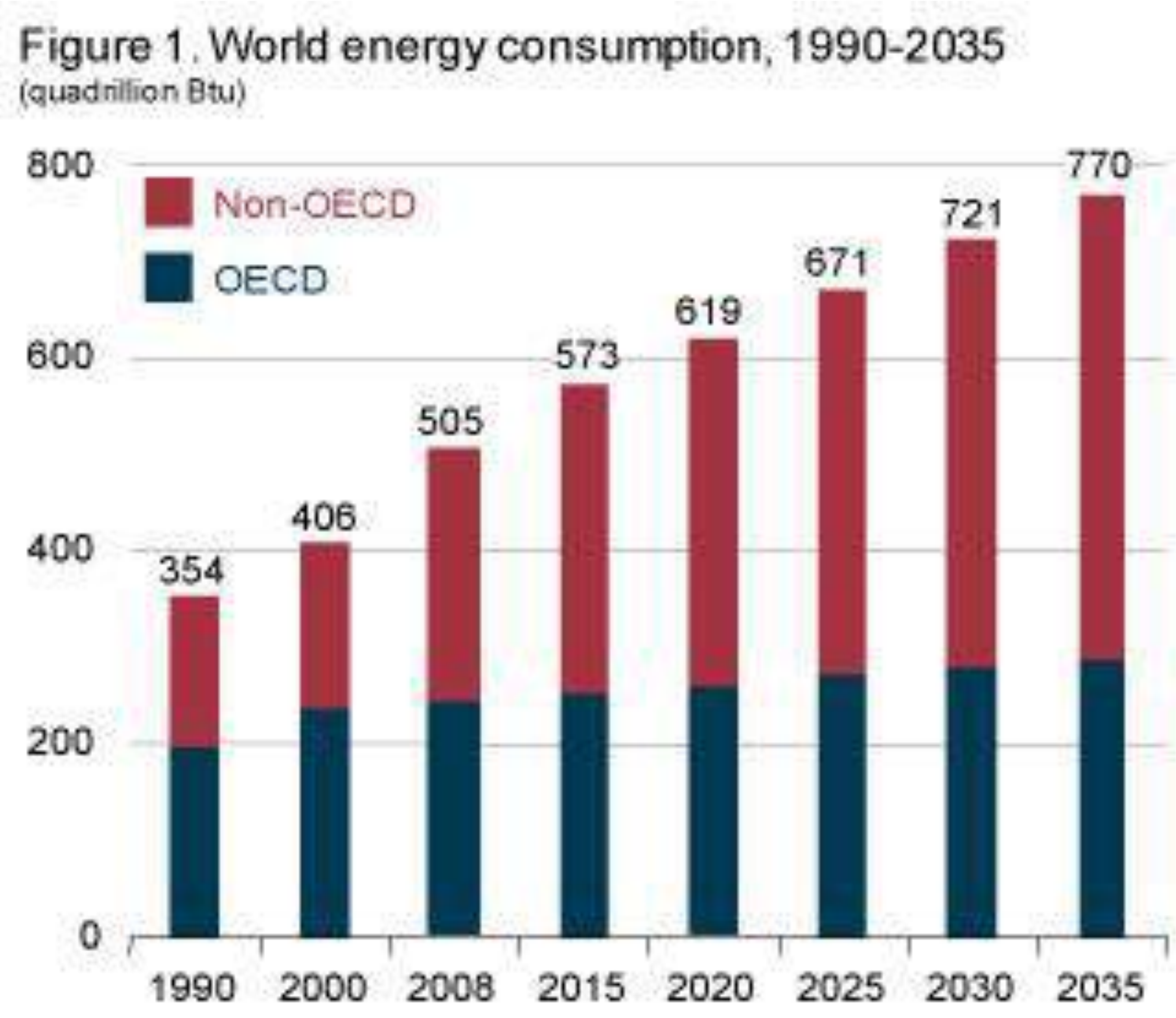
U.S. Energy Information Administration projects 48% increase in world energy consumption by 2040



https://www.eia.gov/todayinenergy/detail.php?id=26212

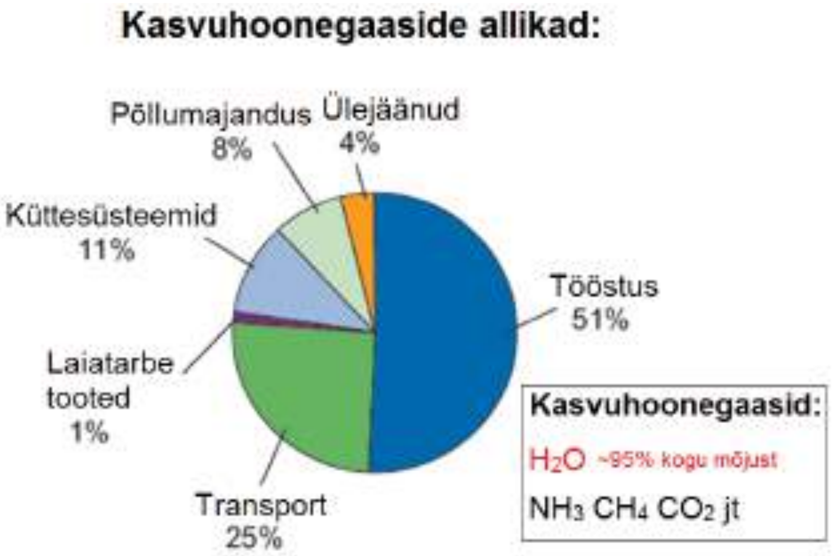


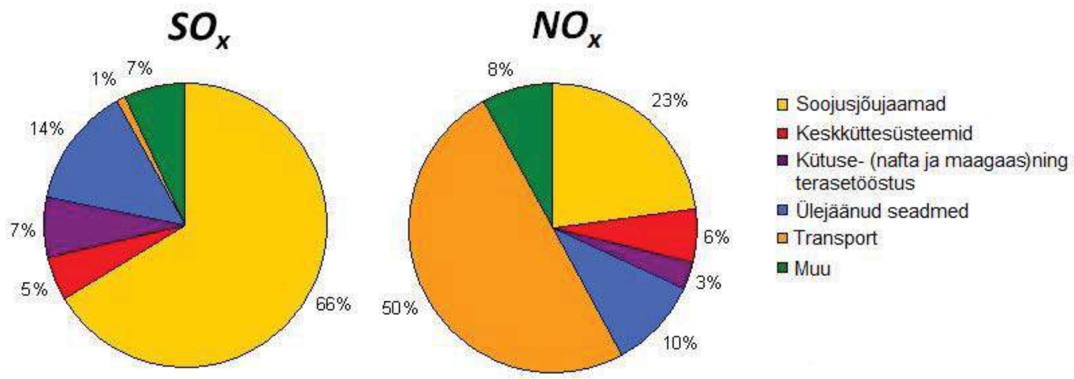
https://en.wikipedia.org/wiki/List_of_countries_by_energy_consumption_per_capita

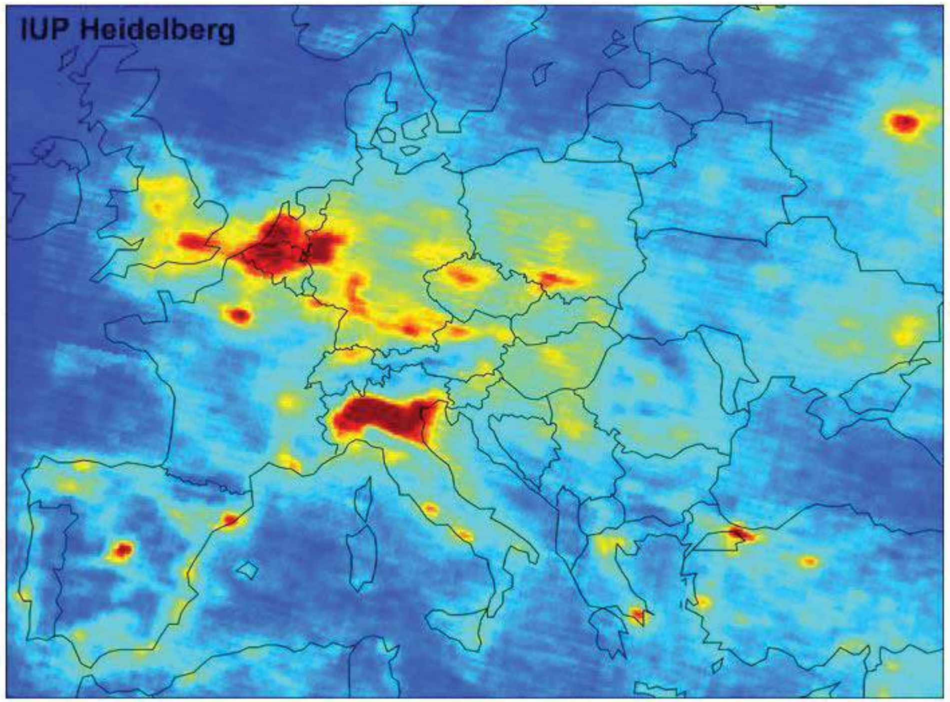


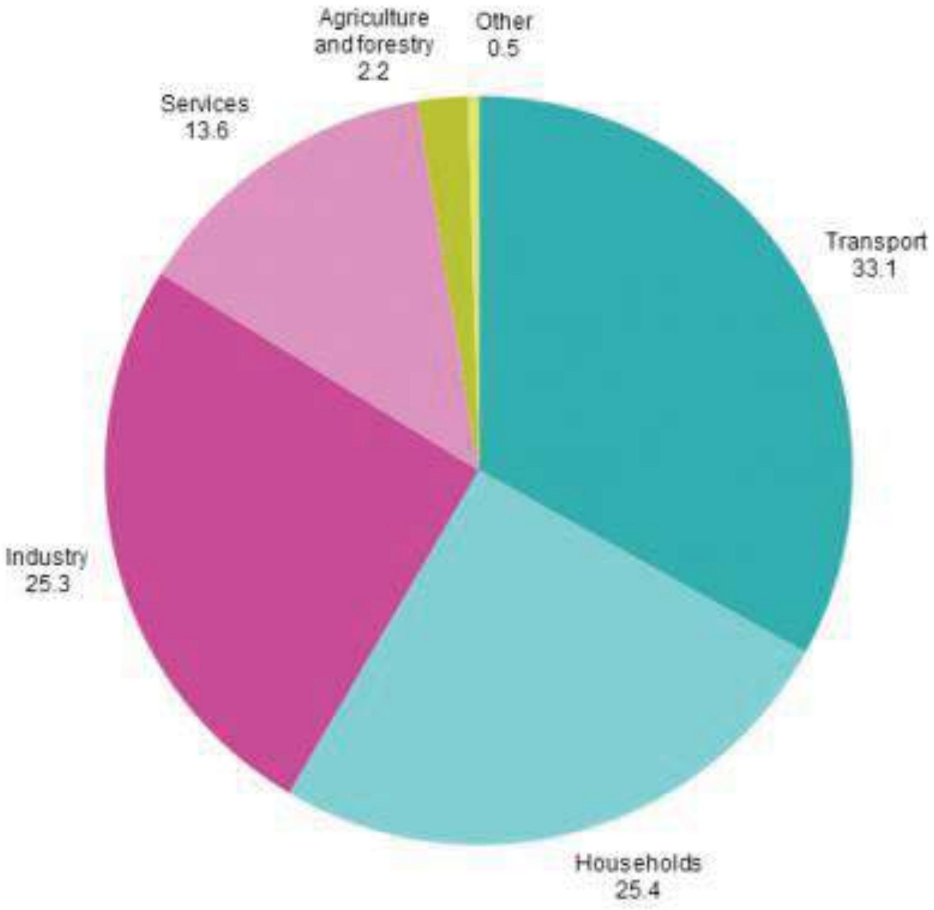
http://www.eia.gov/forecasts/ieo/

Kasvuhoonegaaside tootmine maailmas



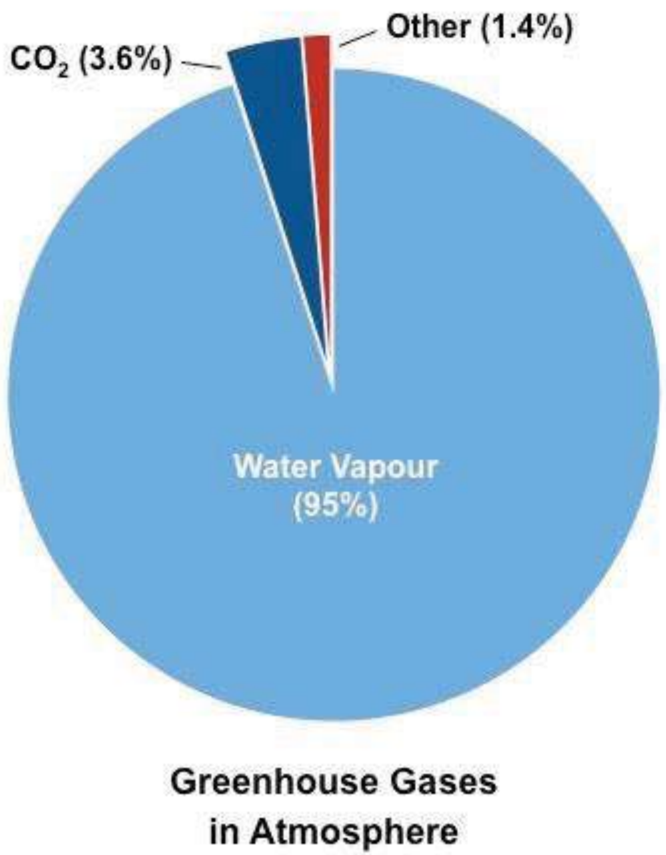


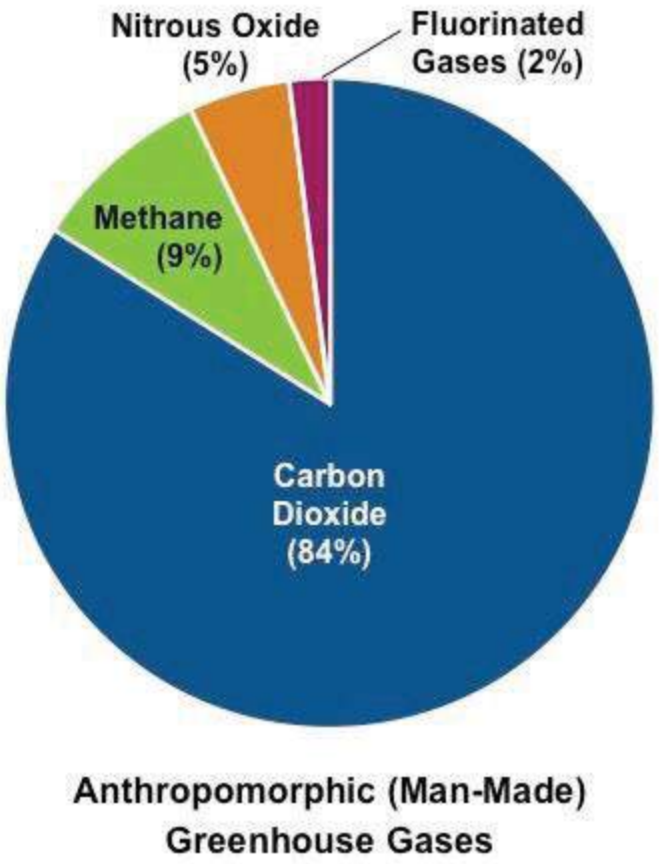




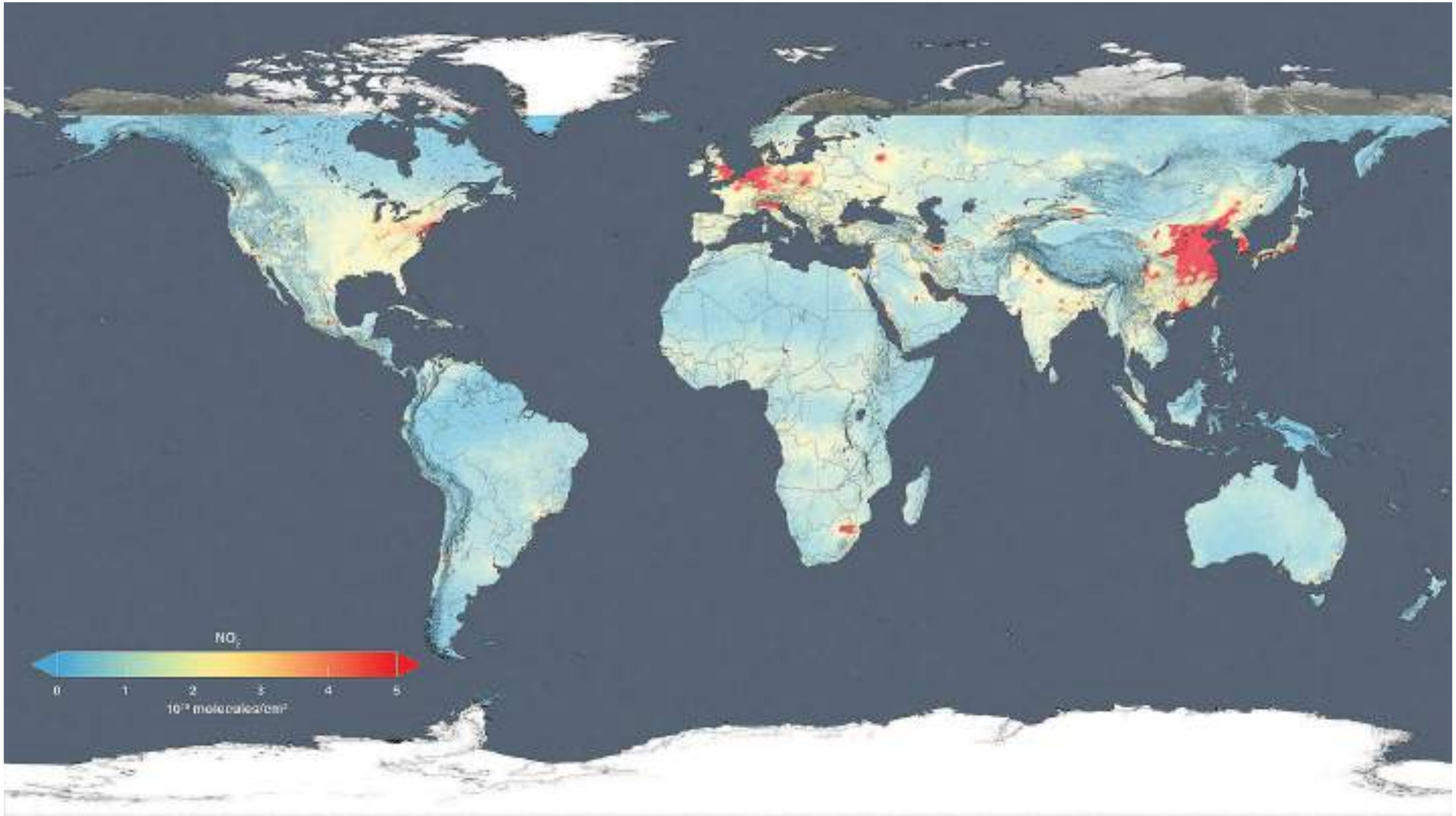
Note: figures do not sum to 100.0 % due to rounding.
Source: Eurostat (online data code: nrg_100a)

http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Final_energy_consumption,_EU-28,_2015_(%25_of_total,_based_on_tonnes_of_oil_equivalent)_YB17.png



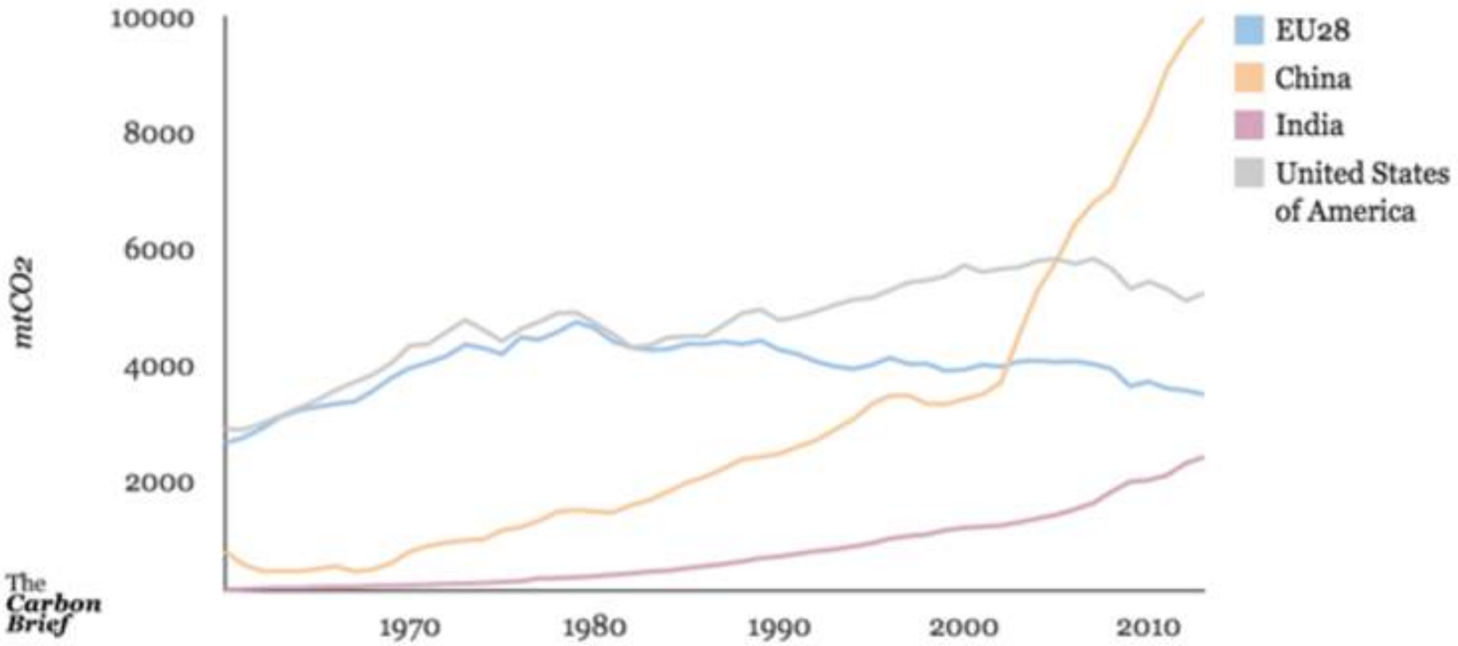


http://ib.bioninja.com.au/standard-level/topic-4-ecology/44-climate-change/greenhouse-gases.html



https://et.wikipedia.org/wiki/Kasvuhoonegaasid#/media/File:15-233-Earth-GlobalAirQuality-2014NitrogenDioxideLevels-20151214.jpg

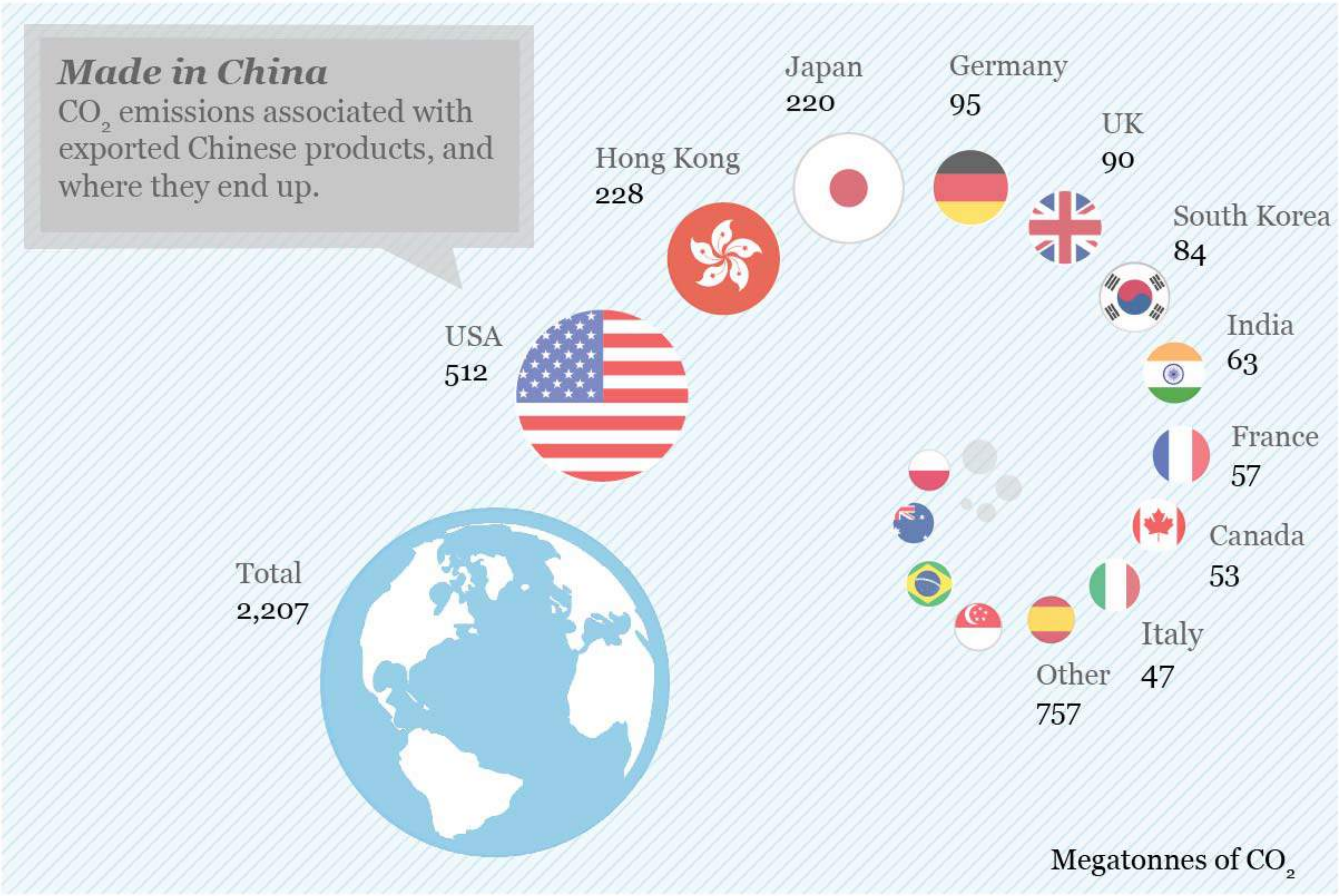
This graph shows the dramatic step change in the growth of China's carbon dioxide emissions that's taken place in the last 15 years:



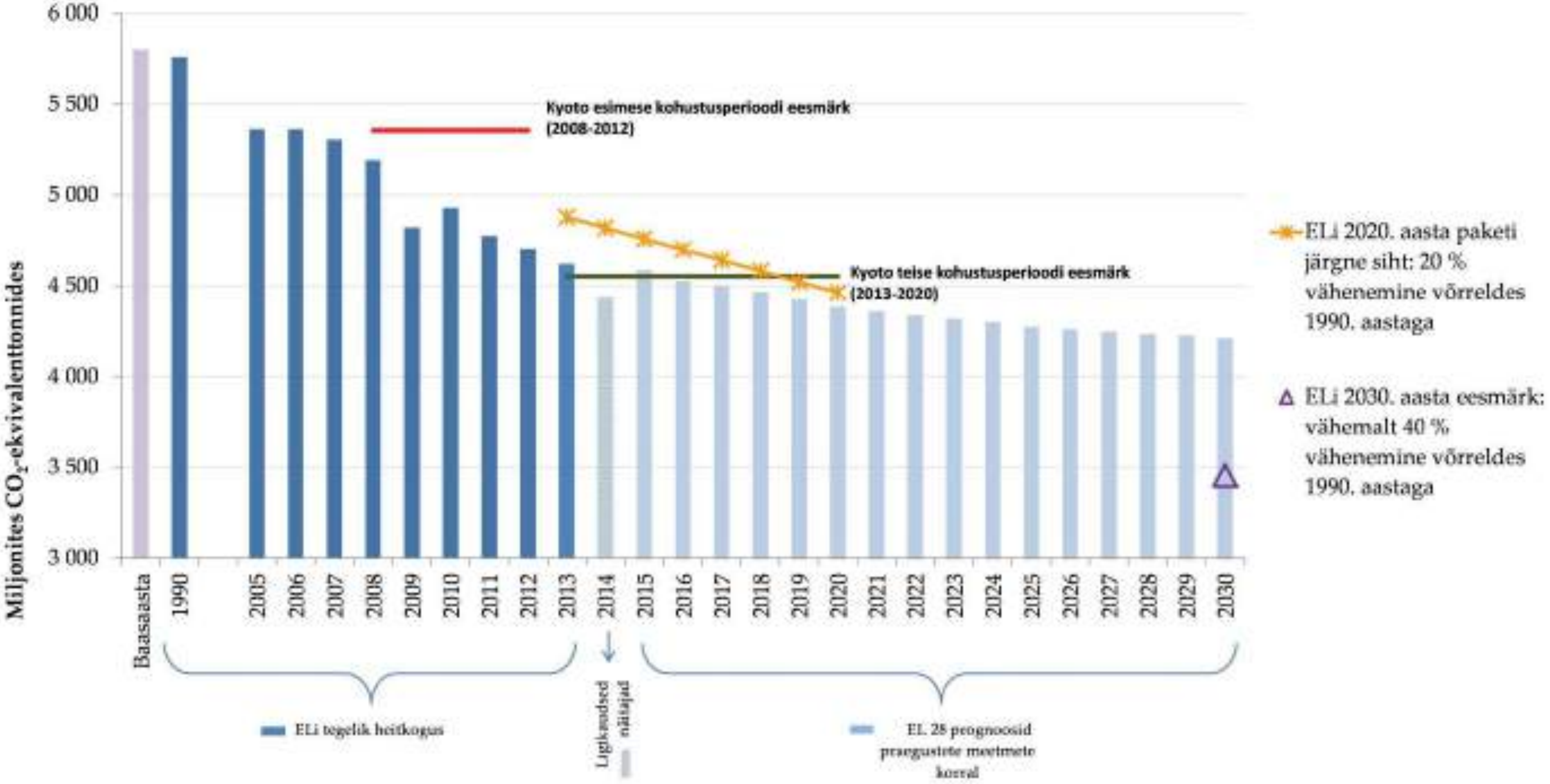
Source: Data from the Global Carbon Project, Global Carbon Atlas. Graph by Carbon Brief.

As China's economy has boomed, emissions have grown – fast.

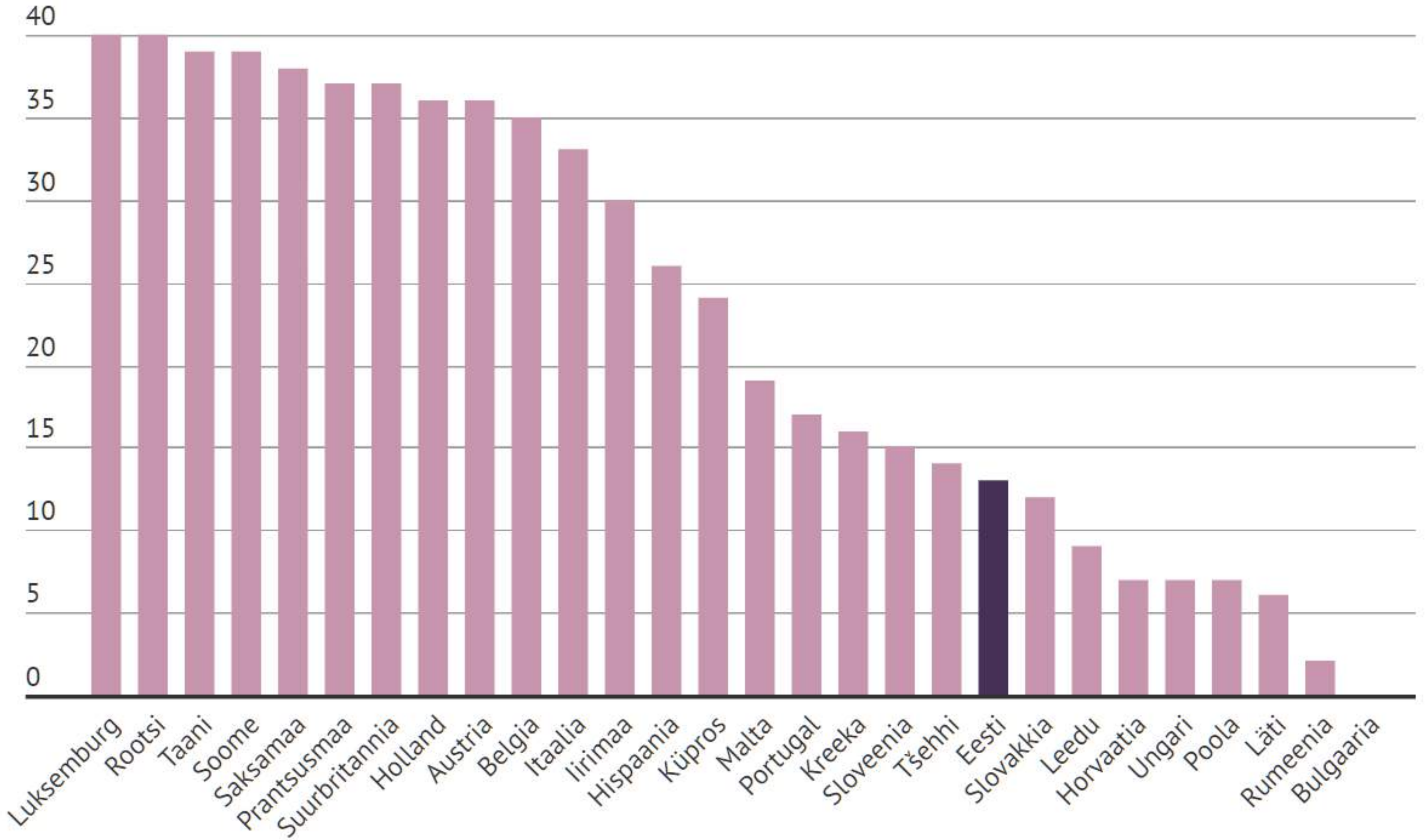
http://www.carbonbrief.org/how-much-of-chinas-carbon-dioxide-emissions-is-the-rest-of-the-world-responsible-for



http://www.carbonbrief.org/how-much-of-chinas-carbon-dioxide-emissions-is-the-rest-of-the-world-responsible-for



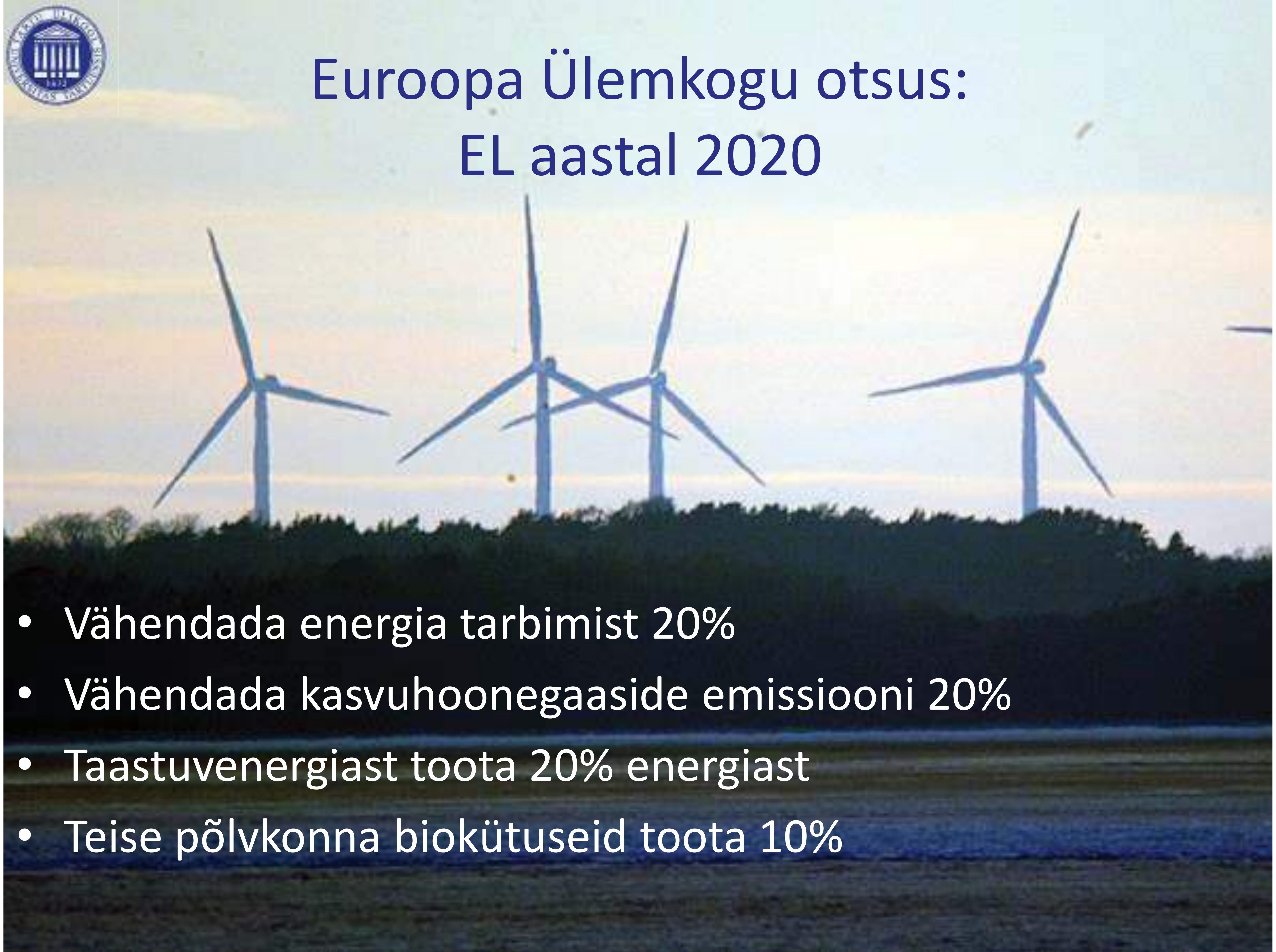
http://eur-lex.europa.eu/legal-content/ET/TXT/?uri=CELEX%3A52015DC0576



Euroopa iga liikmesriik peab 2030. aastaks vähendama süsinikukogust vastavalt suhtelisele jõukusele (võrreldes 2005. aasta emissiooniga

http://www.err.ee/638486/raskelt-sundinud-kliimalepped-euroopa-puuab-rohkem-siduda-ja-vahem-heita

Euroopa Ülemkogu otsus: EL aastal 2020



- Vähendada energia tarbimist 20%
- Vähendada kasvuhoonegaaside emissiooni 20%
- Taastuvenergiast toota 20% energiast
- Teise põlvkonna biokütuseid toota 10%

EU CLEAN FUEL STRATEGY (2020/2025)

ELECTRICITY

- Recharging points connected into networks (Germany, France, Netherland, UK, Spain, Estonia)
- "Type 2" plug as the common standard for the whole of Europe
- USA – 60 million cars
- China - ~6 million cars as well

NATURAL GAS → CNG

LNG

- For waterborne transport and tracks
- Infrastructure in early stage
- 38 filling stations (2012)
- In 2020, 139 refuelling stations are installed every 400 km along the roads

CNG

- 2012: One million vehicles currently use this fuel representing 0.5% of the fleet
- The aims to increase this figure ten-fold by 2020
- refuelling points with maximum distances of 150 km by 2020

HYDROGEN

- Hydrogen refuelling stations (Germany, Denmark, Italy, UK, Spain, Estonia)
- Hydrogen vehicles
- Standardization as a main problem
- 14 member states initiative
- Hydrogen from wind farms, solar systems, etc.

BIOFUELS

- nearly 5% of the market
- A key challenge – sustainability
- Mainly blended fuels
- No specific infrastructure is needed

http://ec.europa.eu/commission_2010-2014/kallas/headlines/news/2013/01/clean-fuel-strategy_en.htm

Elektrienergia osakaal taastuvatest allikatest 2013. aastal (% elektrienergia kogutarbimisest)

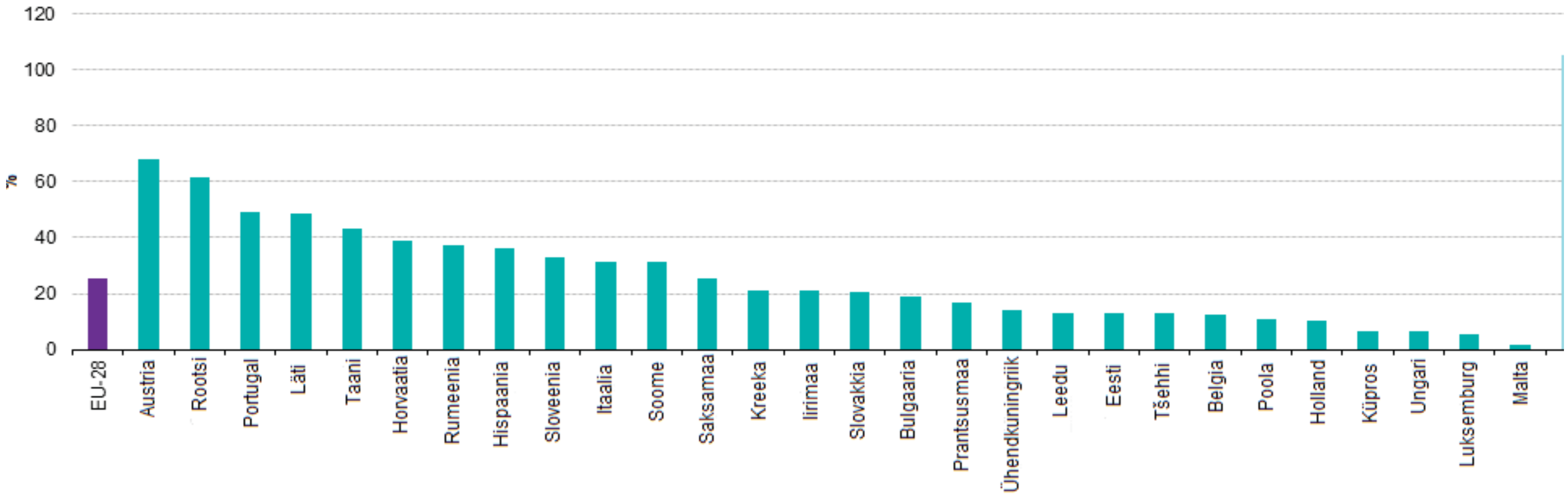
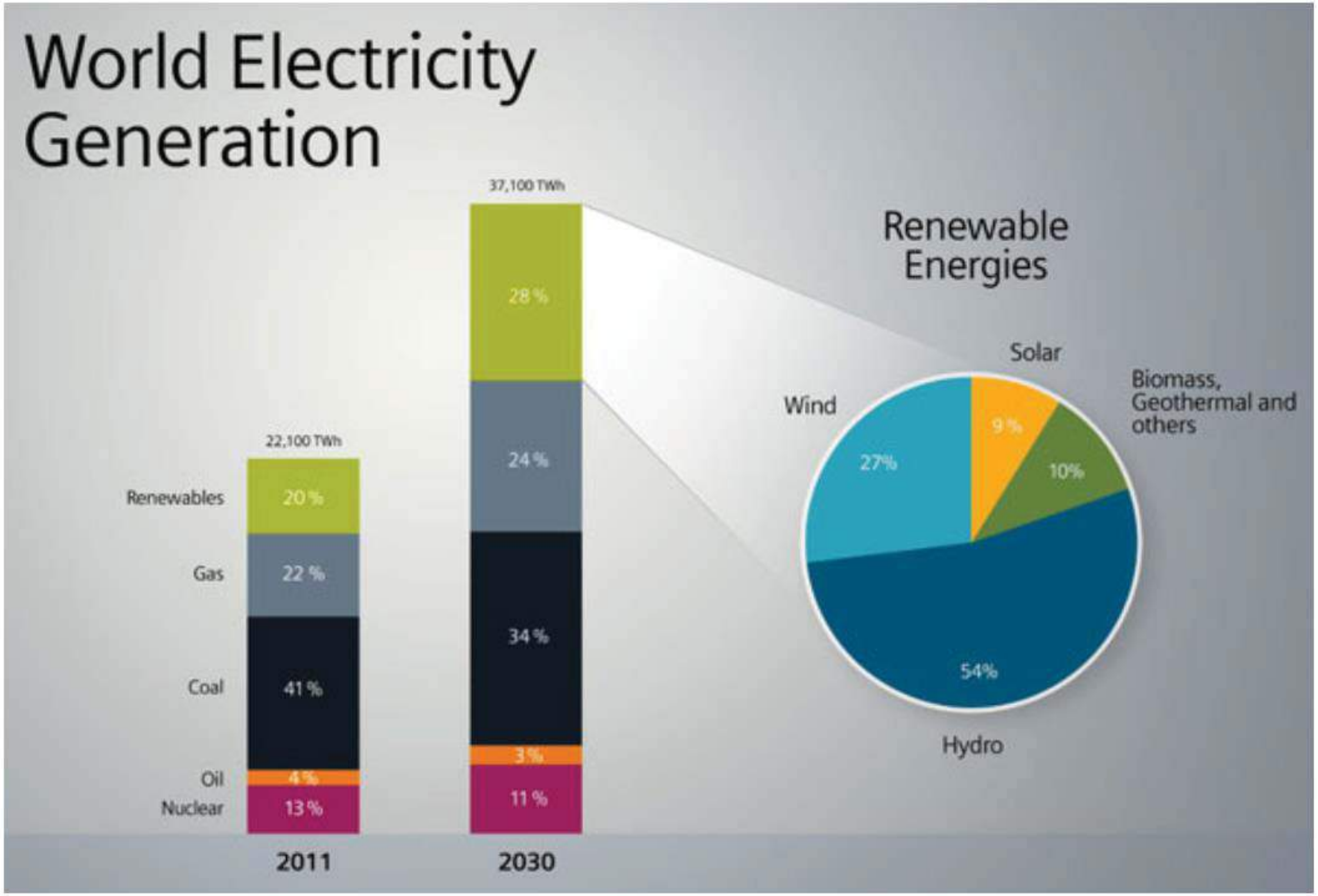


Exhibit 3: Other credible sources figure only an 8% growth over current levels by 2030.

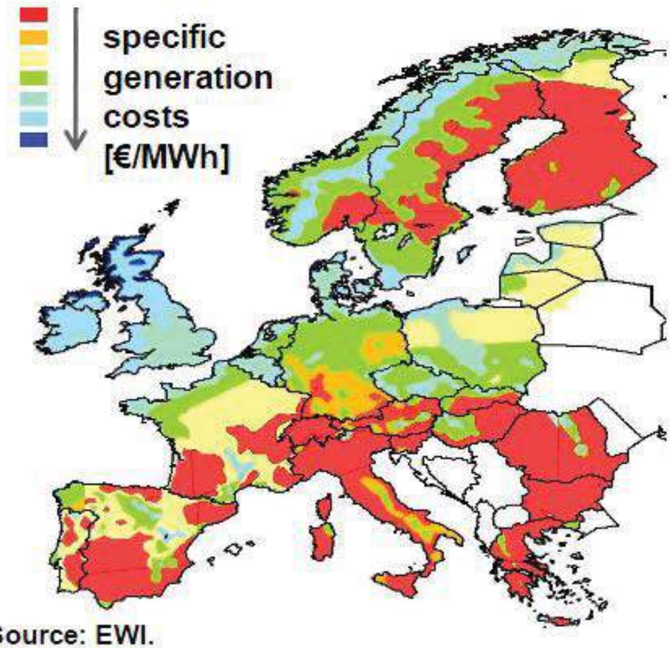


Source: Sustainable Energy Review, Oct, 2012.

https://wattsupwiththat.com/2012/12/10/a-lol-press-release-on-renewable-energy-from-wishful-thinkers-at-the-university-of-delaware/

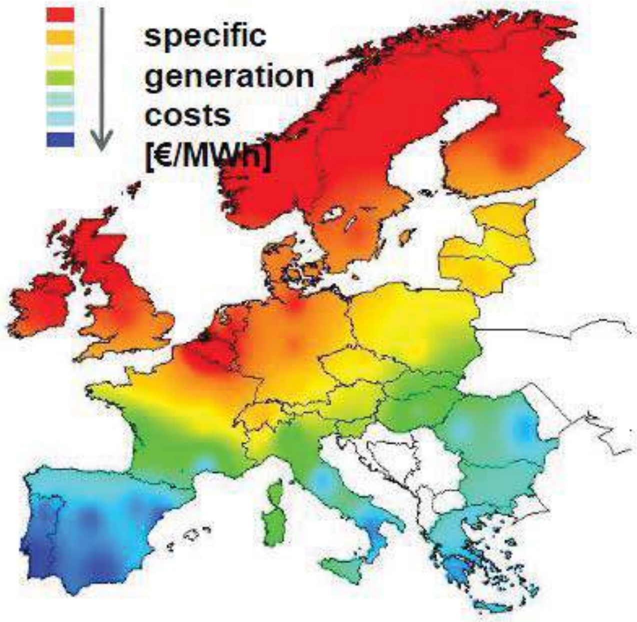
Background / Motivation
RES-E Potentials are heterogenous across Europe

Wind Onshore



Source: EWI.

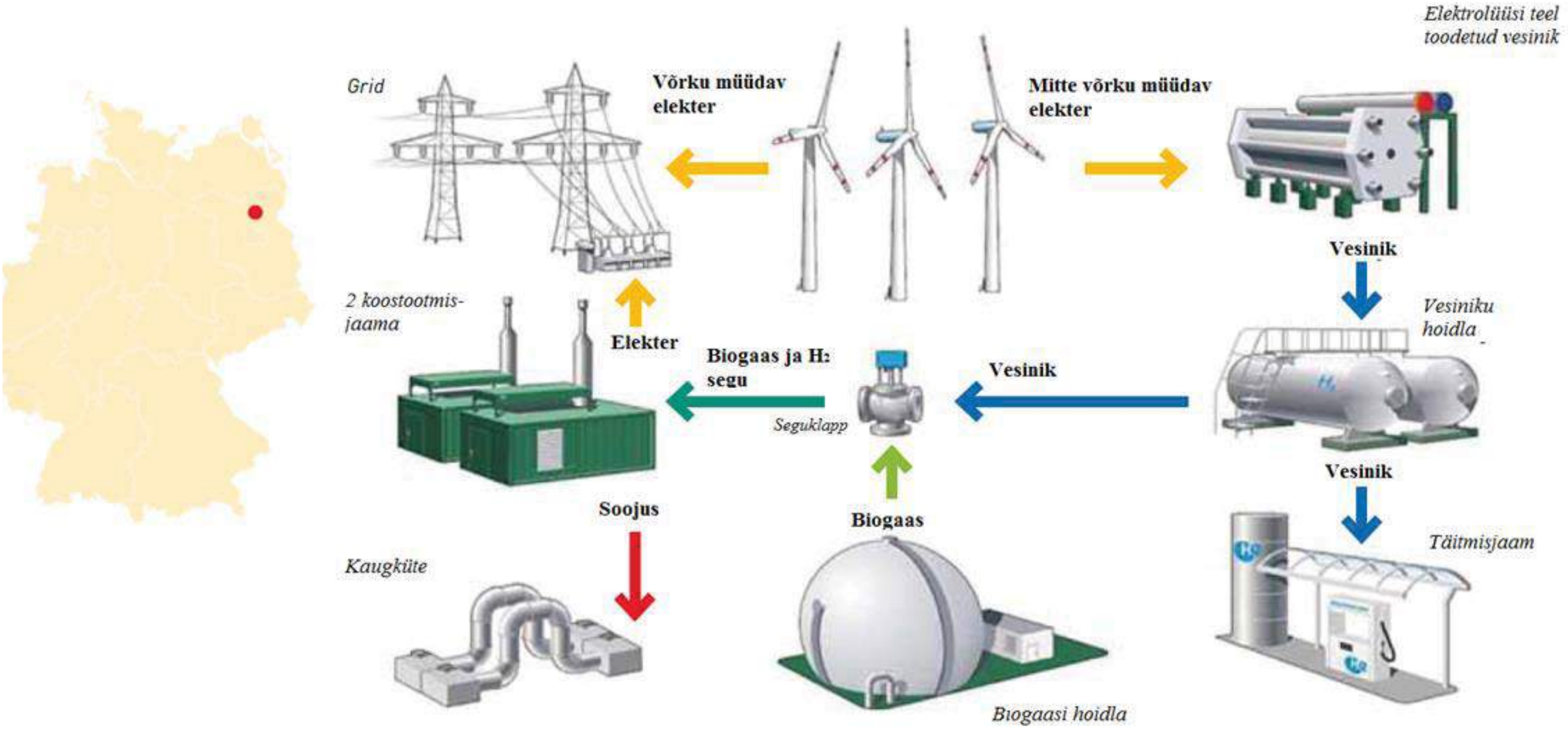
Photovoltaics



Source: EWI.

Use of EU-wide most favorable sites for renewable power generation yields cost savings until 2020 of >100 bn. €, if a sufficient transmission grid is given (EWI, 2010).

Hübriidelektrijaam/süsteemi põhimõtteline skeem



Prototüübi seadmestik hõlmab kolme tuuleturbiini (2 MW/ühiku kohta), mis on ühendatud võrku ja elektrolüüserisse (gaasi tootmine: 120 Nm^3/h vesinikku, 60 Nm^3/h hapnikku, optimaalne rõhk: 15-20 mbar (atm.)), kompressorit (nominaalvool: 2x60 Nm^3/h vesinikku, väljundrõhk: 43 bar (abs.)), statsionaarset vesinikuhoidlat (3 rõhuanumat, hoiustamise maht: 1.350 kg H_2 43 baari juures (abs.)), biogaasi tootmise seadet, mille nominaalne tootmisvõimsus on ca 300 m^3/h ja hoiustamise maht ca 2.600 m^3; ja kahte CHP (kombineeritud soojus ja võimsus) seadet (max. aastane elektri toodangu maht 2.776 mWh ja soojuse toodangu maht 2.250 MWh). See soojusvõimsus on piisav, et soojendada ca 80 üksikpere maja.

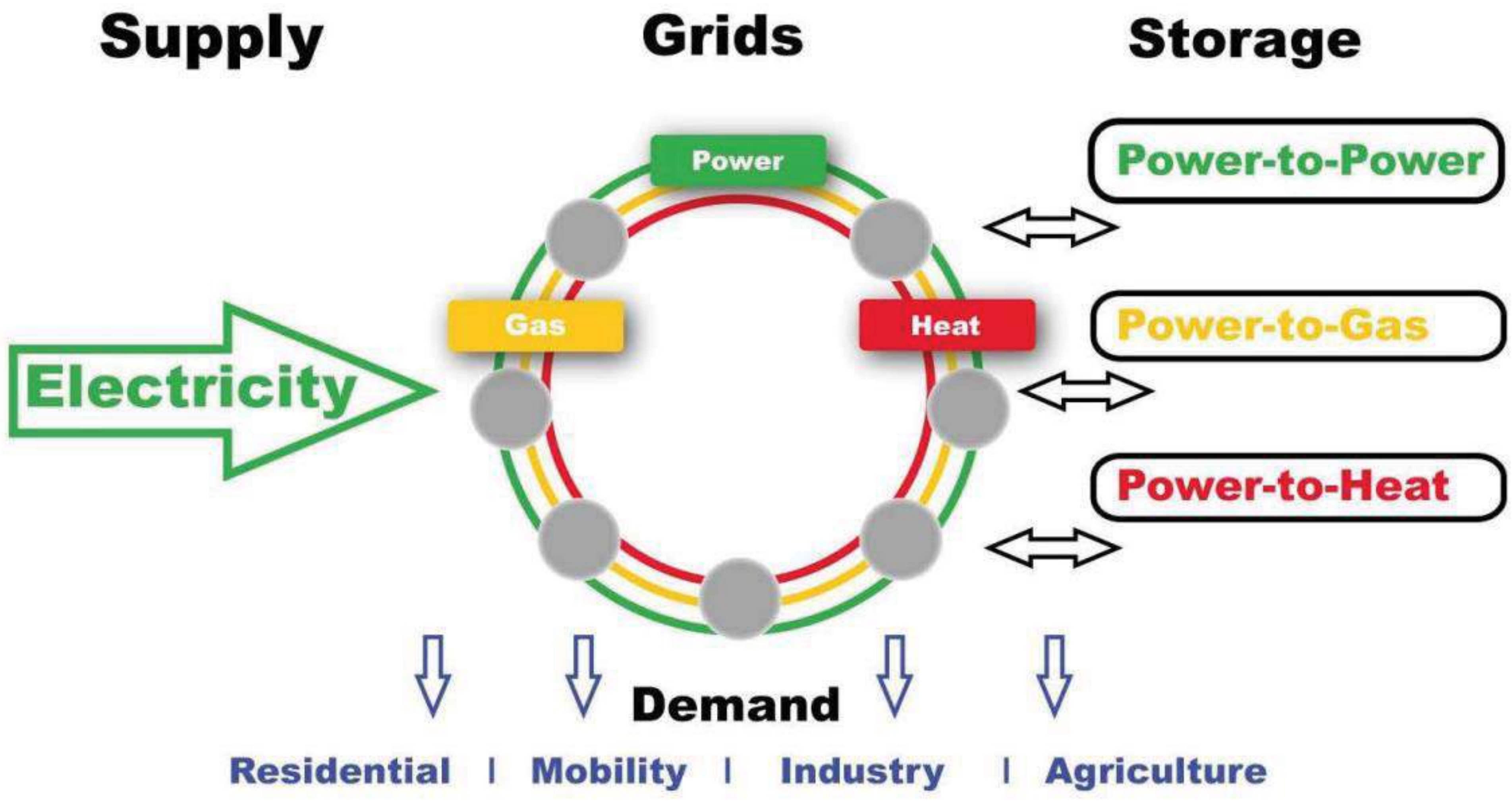
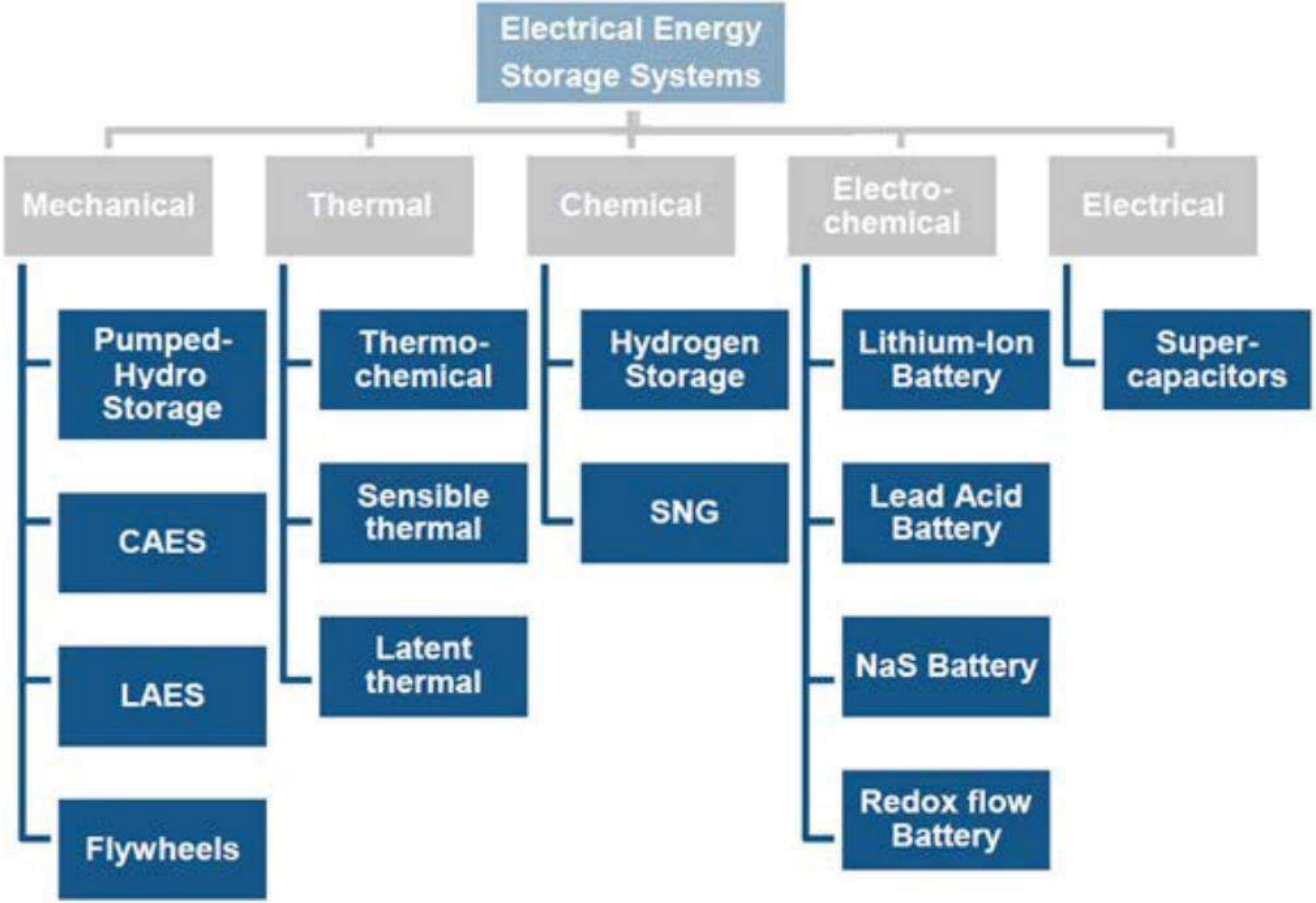


Figure 1. Illustration of flexibility components in the electricity system.

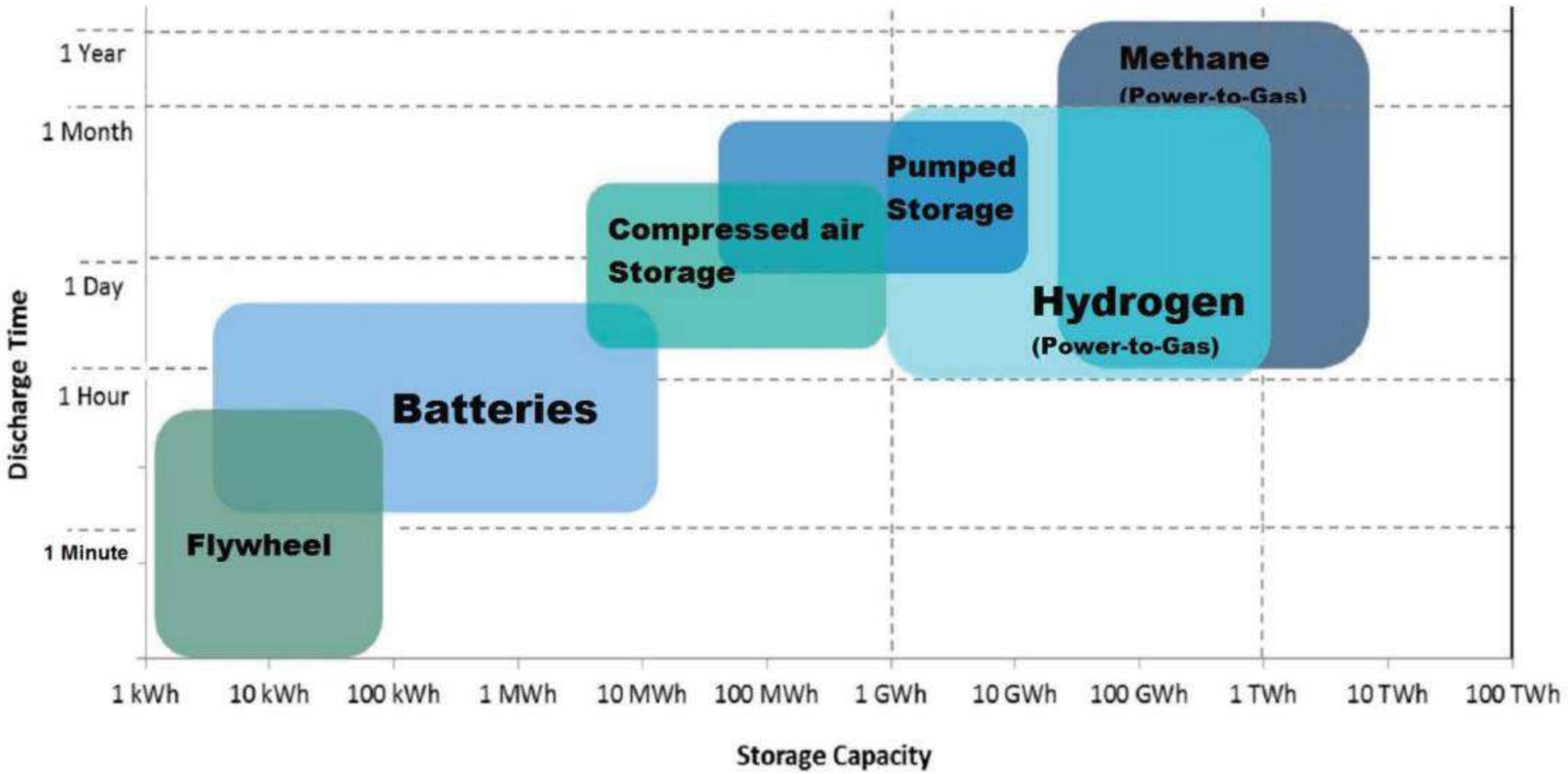
https://ec.europa.eu/energy/sites/ener/files/documents/swd2017_61_document_travail_service_part1_v6.pdf



CAES = Compressed Air Energy Storage; LAES = Liquid Air Energy Storage; SNG = Synthetic Natural Gas.

Figure 2. Example of energy storage types (source: World Energy Council)

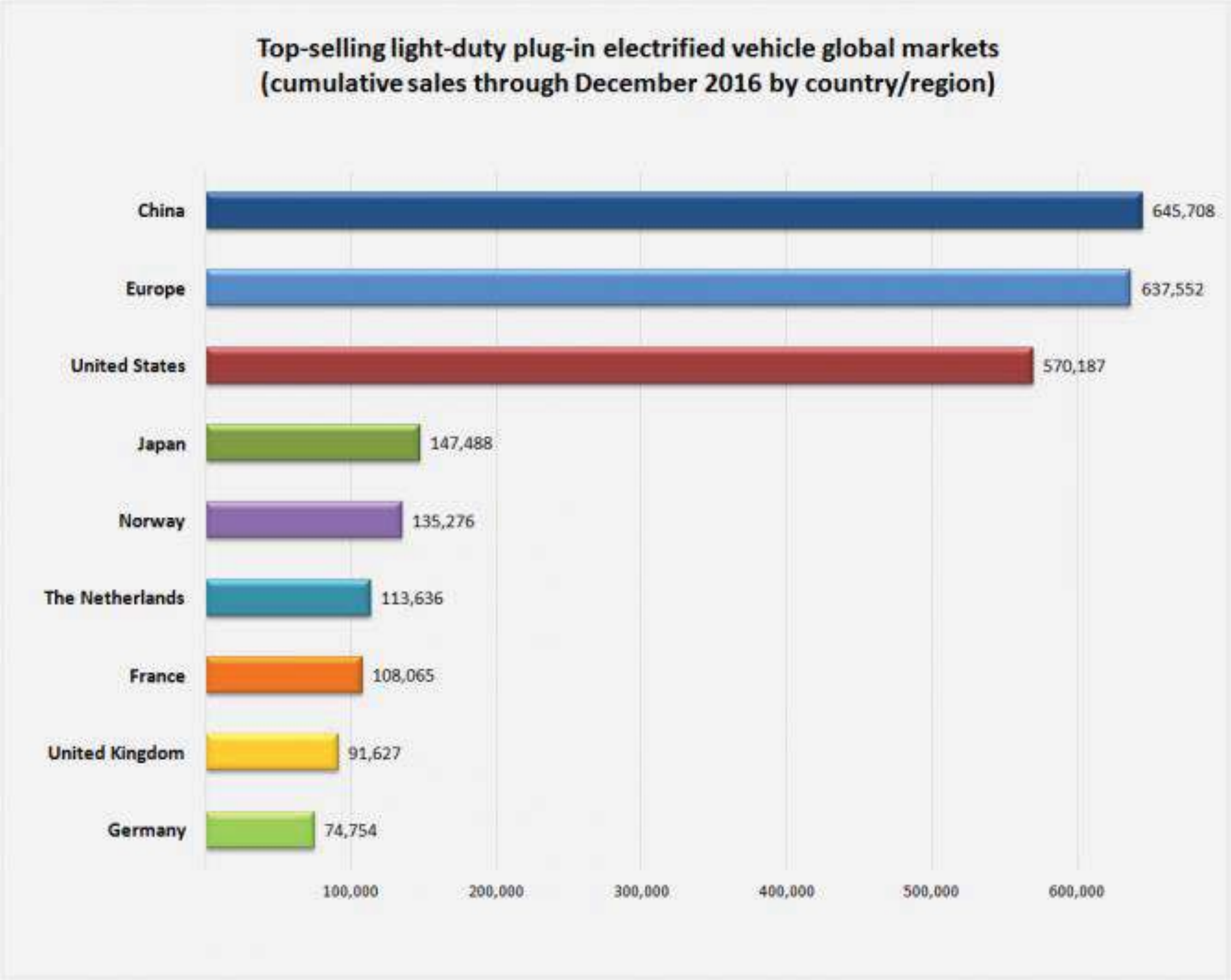
https://ec.europa.eu/energy/sites/ener/files/documents/swd2017_61_document_travail_service_part1_v6.pdf



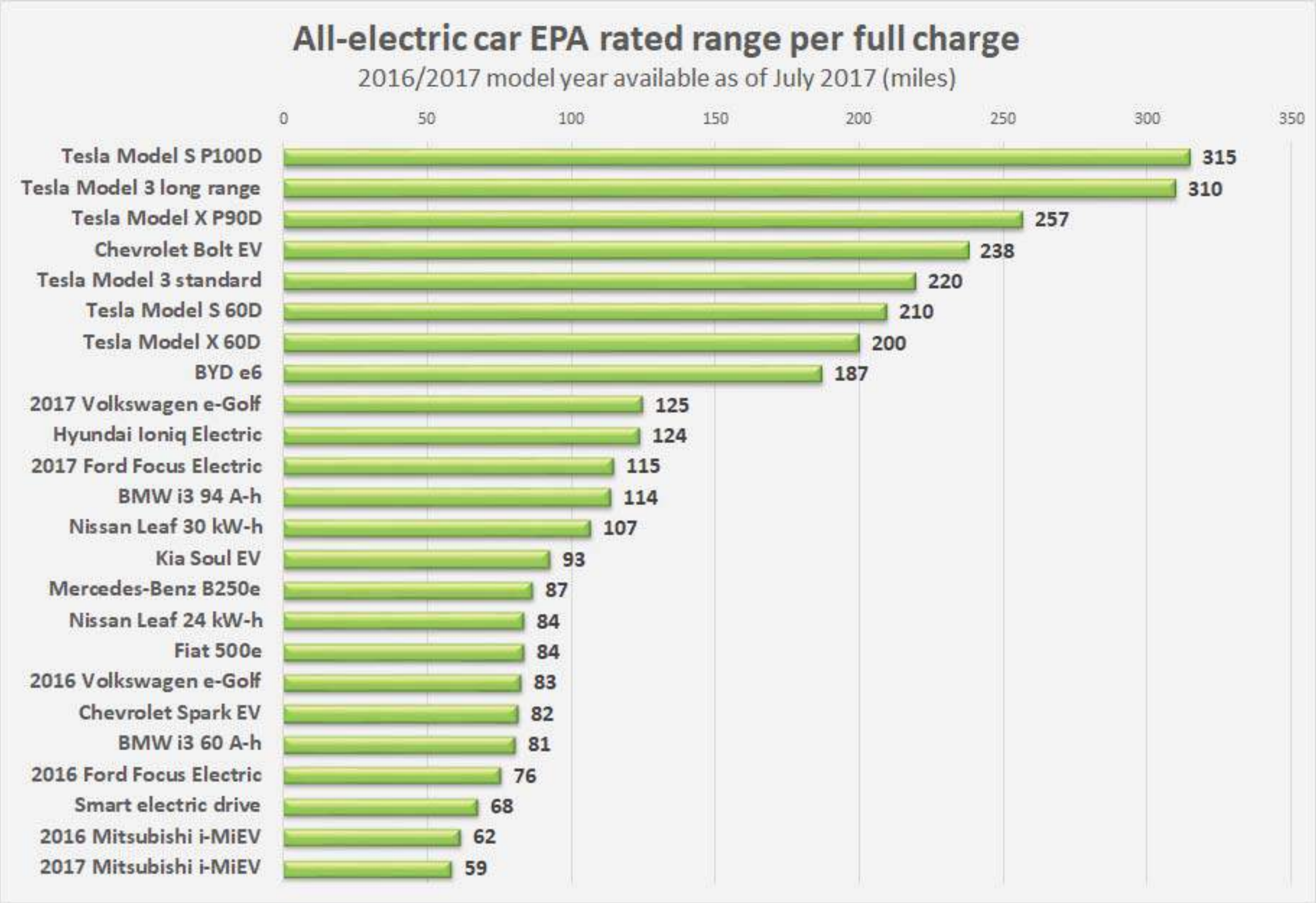
Source: School of Engineering, RMIT University (2015)

Figure 3. Available storage technologies, their capacity and discharge time.

https://ec.europa.eu/energy/sites/ener/files/documents/swd2017_61_document_travail_service_part1_v6.pdf

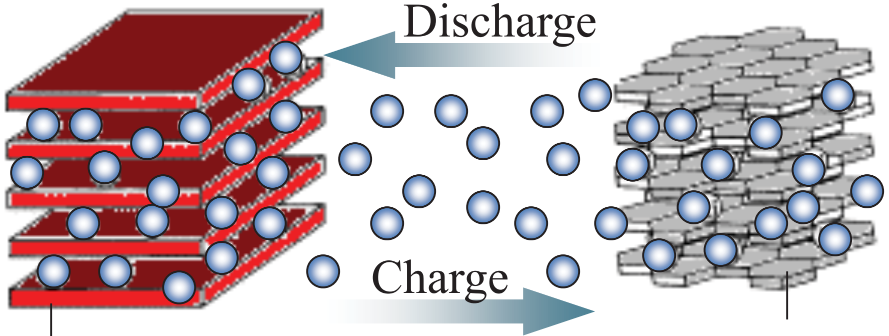


http://www.hybridcars.com/the-world-just-bought-its-two-millionth-plug-in-car/



https://en.wikipedia.org/wiki/Electric_car#/media/File:BEV_EPA_range_comparison_2016-2017_MY_US.png

Lithium-ion and Na-ion batteries



Cathode:

$LiMe O_2$ - xe- $\underset{\text{DISCHARGE}}{\overset{\text{CHARGE}}{\rightleftarrows}}$ $Li_{1-x}MeO_2$ + xLi+

Anode:

C + xLi+ + xe- $\underset{\text{DISCHARGE}}{\overset{\text{CHARGE}}{\rightleftarrows}}$ CLi_x

Cathode ($LiMe_xO_y$)

$LiCoO_2$ -utilized for commercial batteries

$LiNiO_2$, $LiMn_2O_4$-prospective

Li+-ioon-patareid
➔väga palju erinevaid modifikatsioone
➔ limiteeriv staadium on Li+ interkaleerumine (tungimine) grafiidikihtide vahele

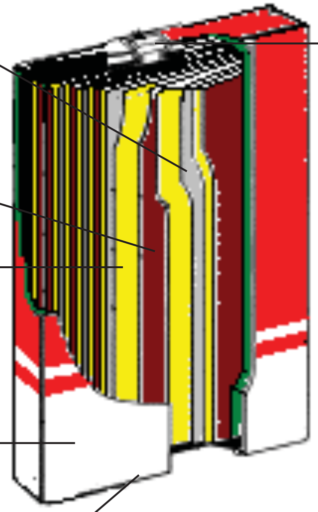
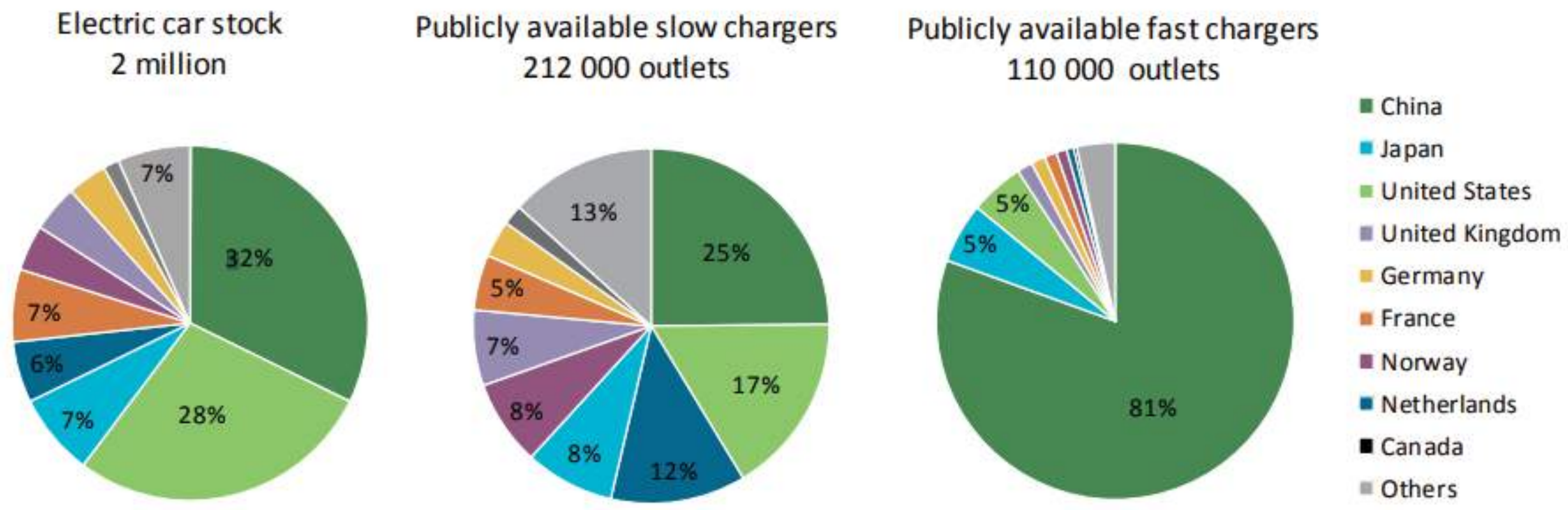


Figure 12 • Electric car stock and publicly available EVSE outlets, by country and type of charger, 2016

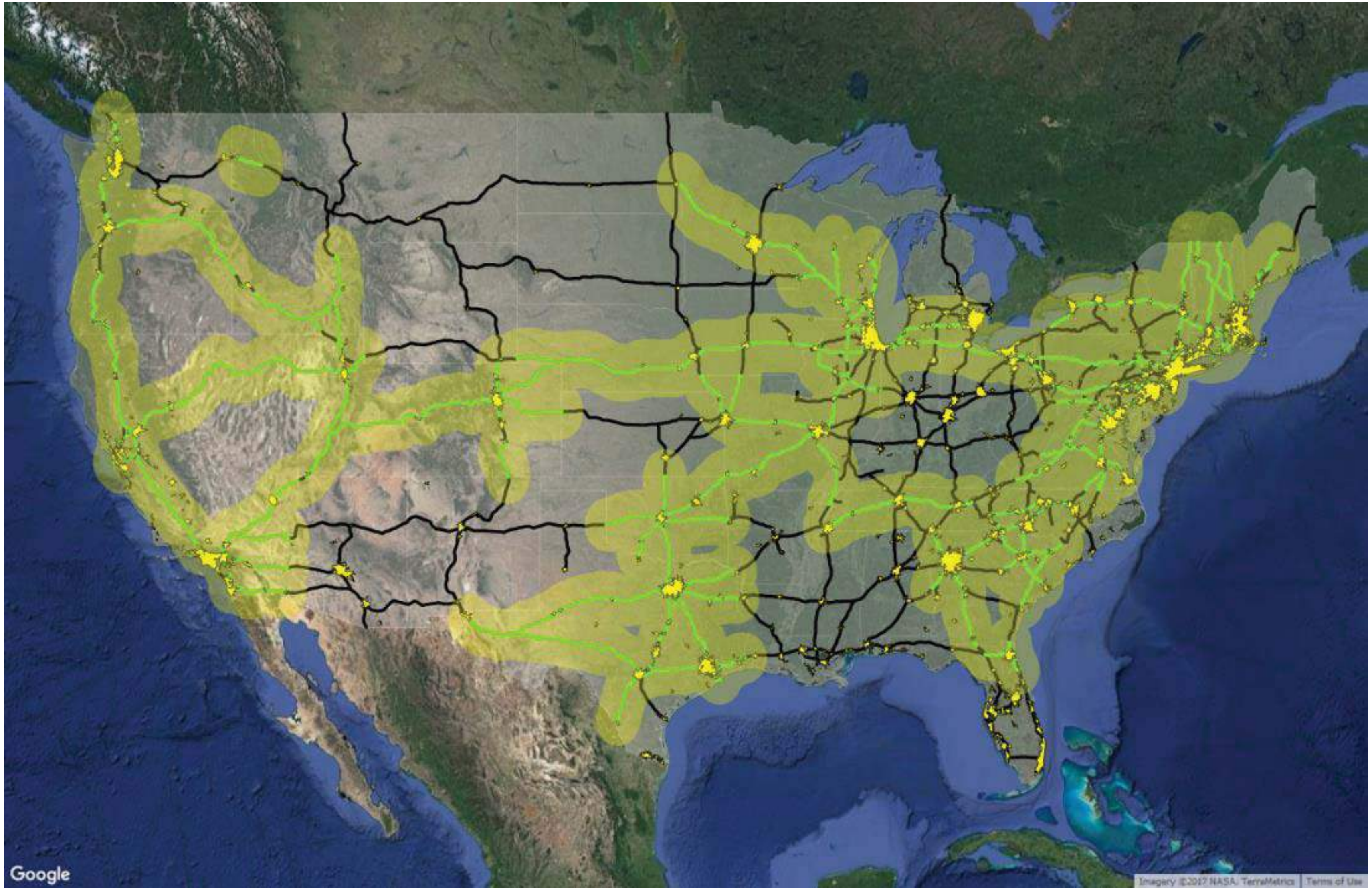


Sources: IEA analysis based on EVI country submissions, complemented by EAFO (2017a).

Key point: Electric cars still outnumber public charging stations by more than six to one, indicating that most drivers rely primarily on private charging stations. Publicly available EVSE shares are not evenly distributed across markets. This is consistent with the early stage of electric car deployment.

https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf

The Future of Electric Charging Stations Projected in 4 Simple Maps



Next stage: 96 to 239 fast-charging stations depending on station spacing

https://energy.gov/eere/articles/future-electric-charging-stations-projected-4-simple-maps

Optimaalne ja mõõdukas elektrivõrgu laienduse kava Euroopas.

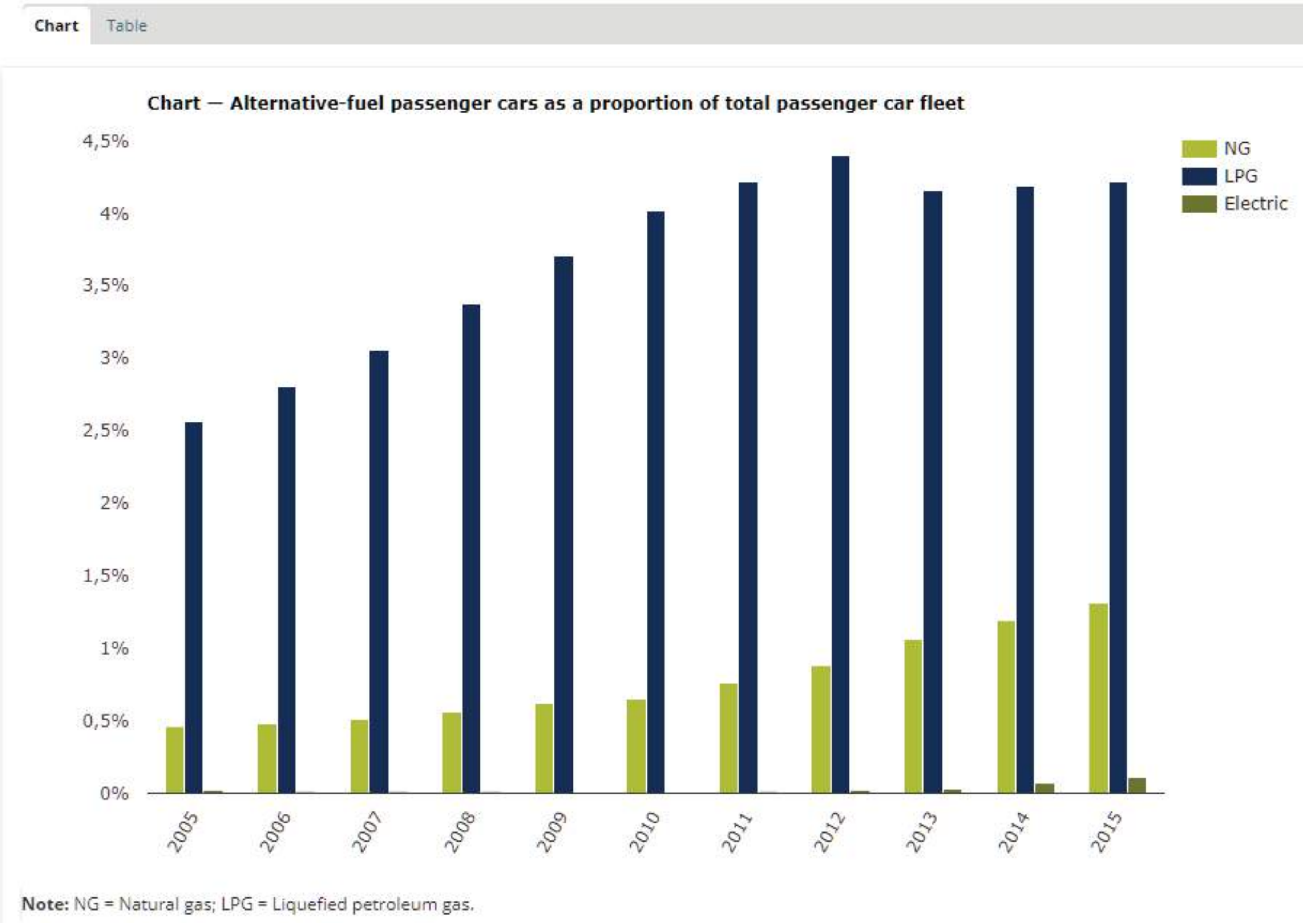
Optimaalne võrgustikulaiendus

+ 228,000 km 2050.aastaks
(+76% võrreldes 2010. aastaga)

Modereeritud võrgustiku laiendus

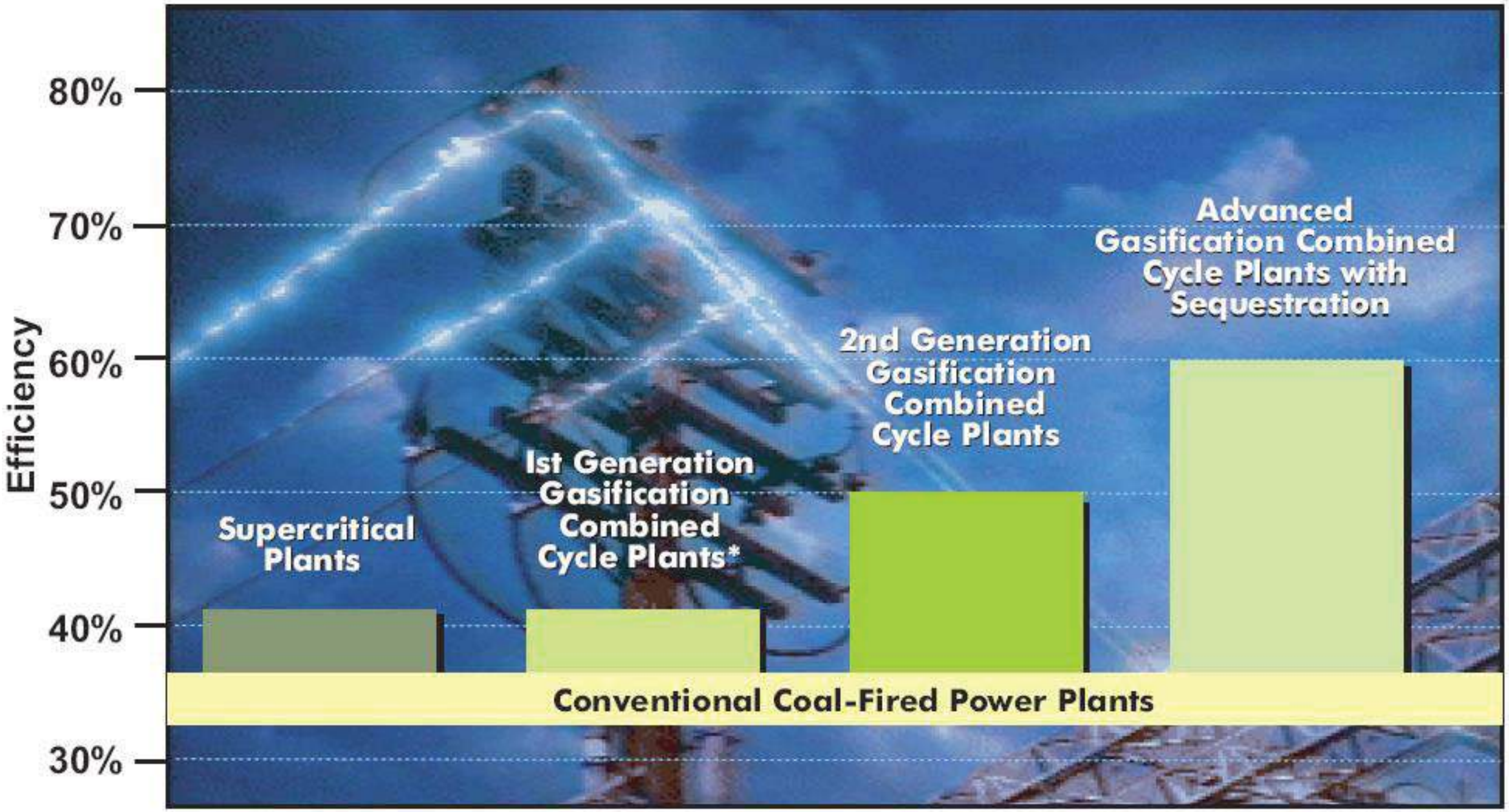
+111,000 2050.aastaks
(+37% võrreldses 2010. aastaga)

Fig. 2: Alternative-fuel passenger cars as a proportion of total passenger car fleet



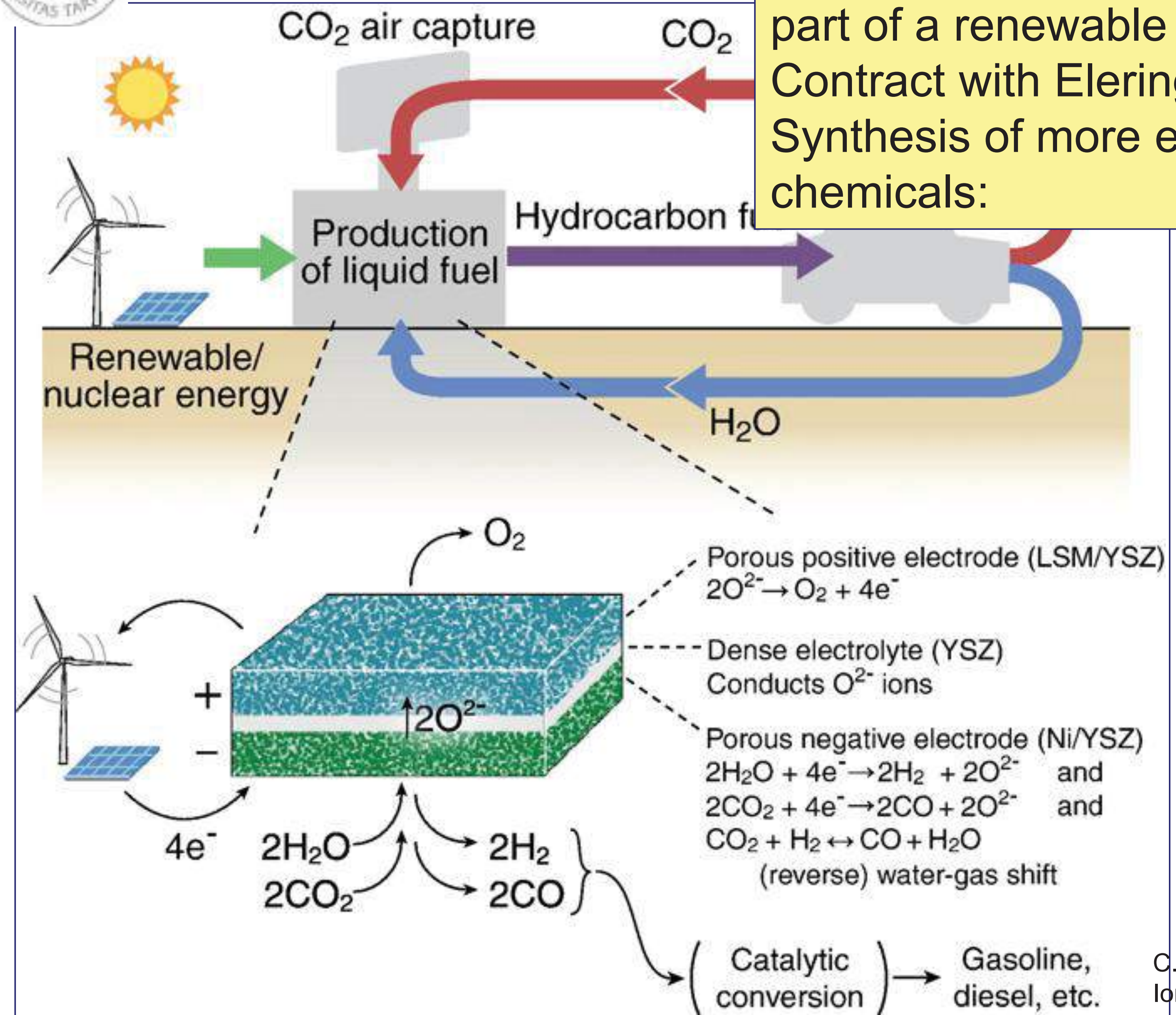
https://www.eea.europa.eu/data-and-maps/indicators/proportion-of-vehicle-fleet-meeting-4/assessment-1

Efficiency Gains from Next Generation Coal-Based Electric Power Systems



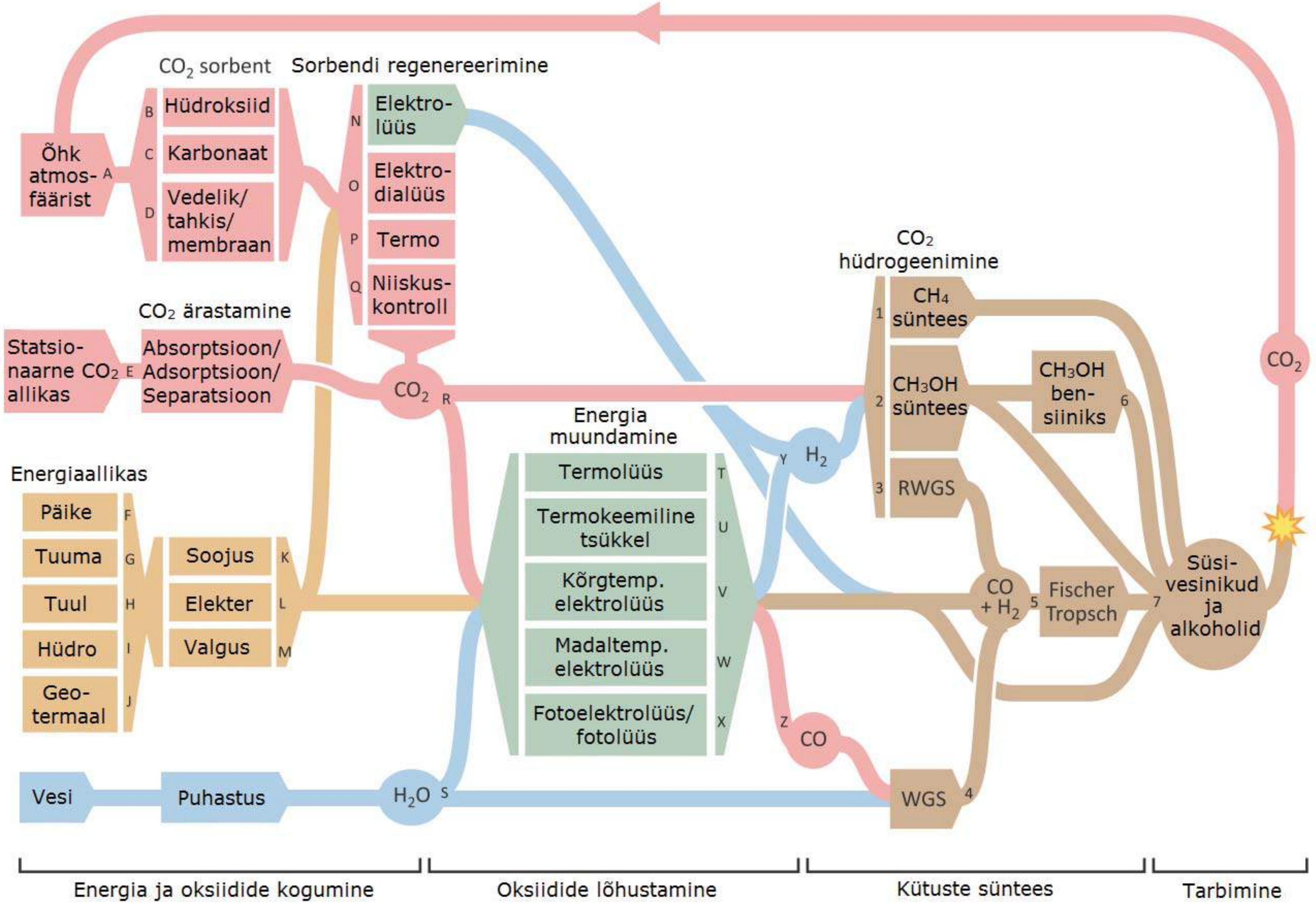
* Demonstrated in original Clean Coal Technology Program

Diagram of co-electrolysis of CO_2 and H_2O in a solid oxide cell, as part of a renewable fuel cycle: Contract with Elering AS- Synthesis of more expensive chemicals:

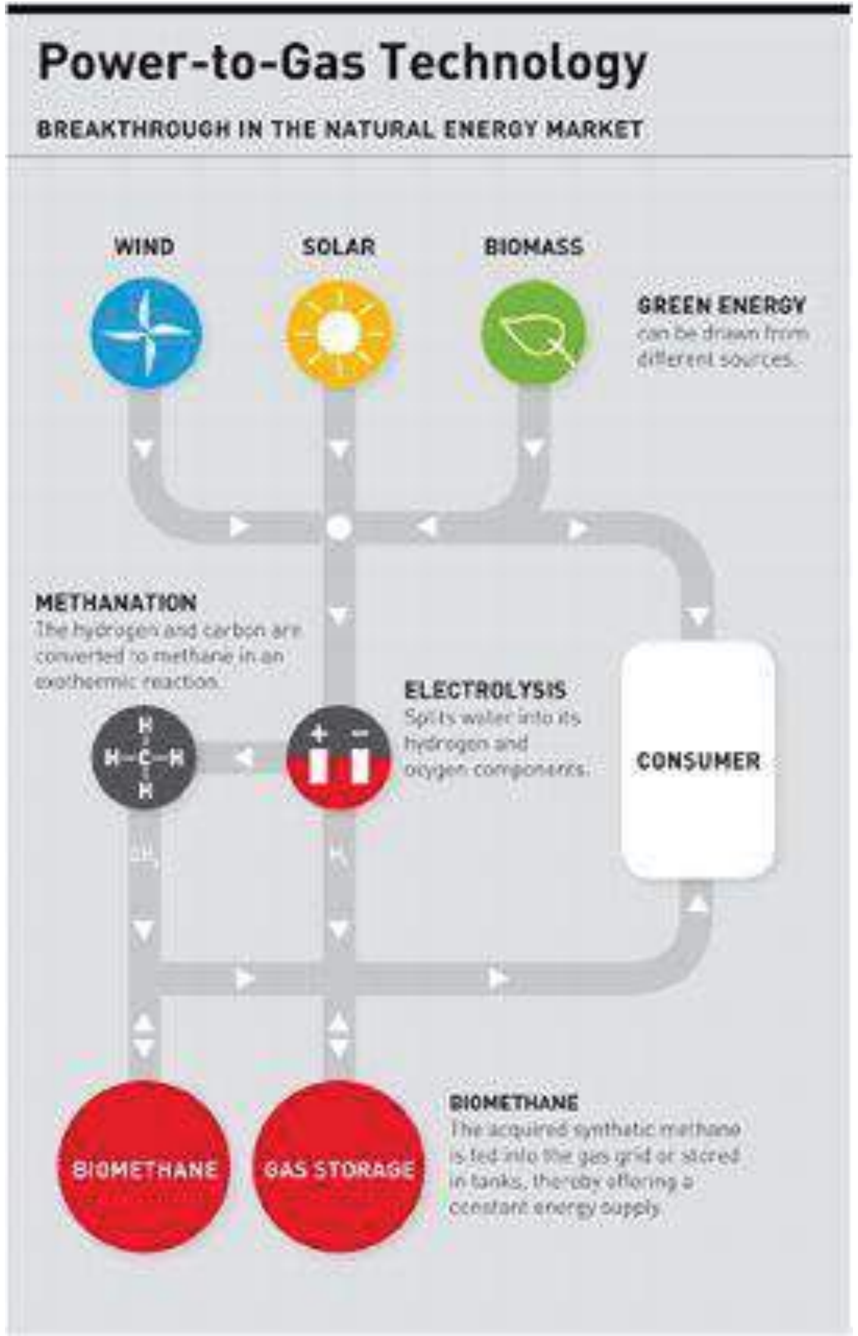


C. Graves et al. / Solid State Ionics 192 (2011) 398–403.

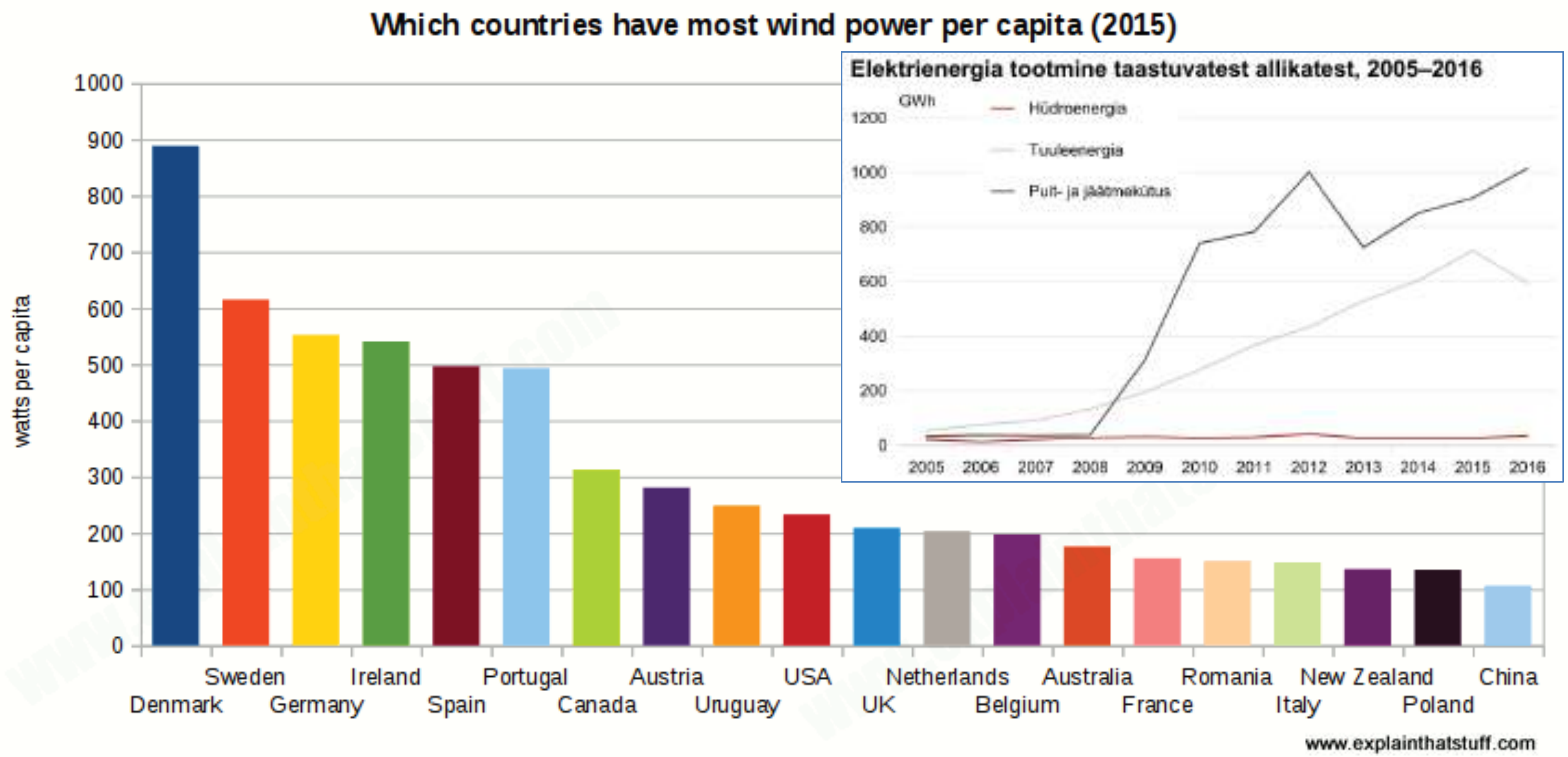
Veest ja CO_2-st kütuste tootmise võimalikud teed



Fischer-Tropsch süntees hõlmab kõikvõimalikke katalüütilisi kütuste sünteesimise protsesse. WGS – (*water-gas shift*) vesi-gaasi reaktsioon, RWGS – (*reverse water-gas shift*) pöördvesi-gaasi reaktsioon.

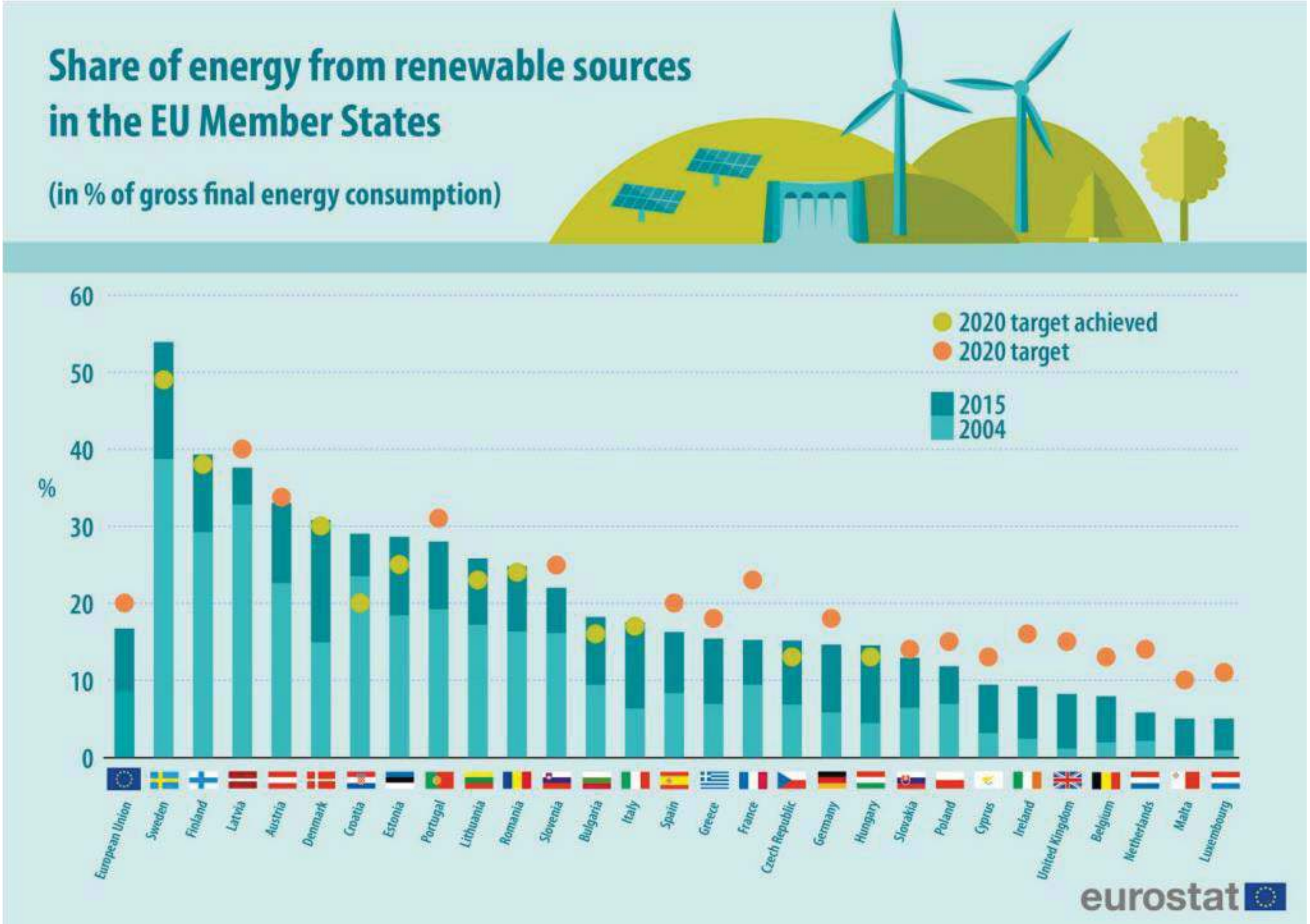

Power-to-Gas Technology
BREAKTHROUGH IN THE NATURAL ENERGY MARKET
WIND
SOLAR
BIOMASS
GREEN ENERGY
can be drawn from different sources.
METHANATION
The hydrogen and carbon are converted to methane in an exothermic reaction.
ELECTROLYSIS
Splits water into its hydrogen and oxygen components.
CONSUMER
BIOMETHANE
GAS STORAGE
BIOMETHANE
The acquired synthetic methane is fed into the gas grid or stored in tanks, thereby offering a constant energy supply.

2016. aastal Eestis 4,9% koguenergiast tuuleenergia, 589 GWh, st installeeritud võimsus **124** W inimese kohta



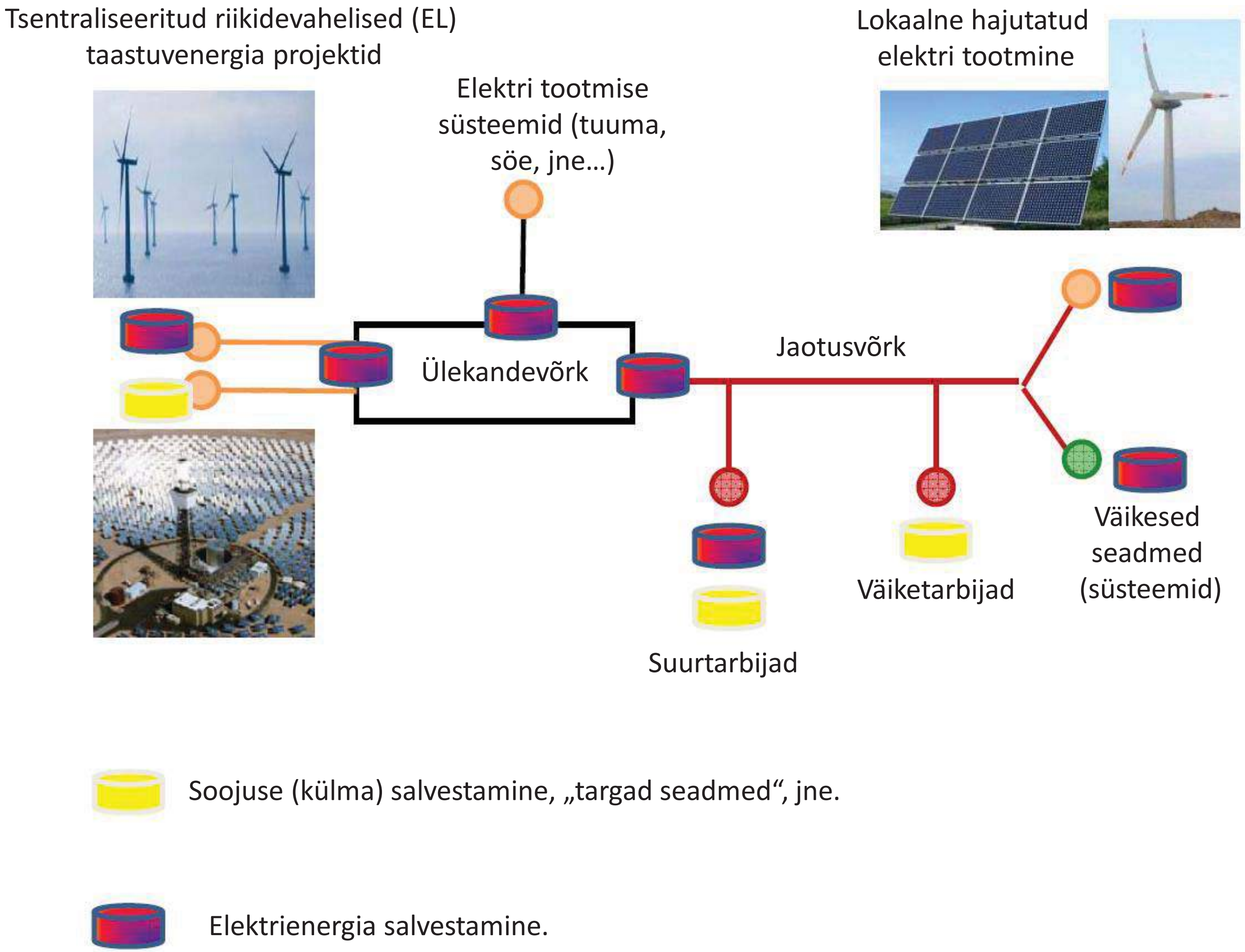
https://www.stat.ee/pressiteade-2017-094?highlight=tuuleenergia

https://cdn4.explainthatstuff.com/wind-power-capacity-watts-per-capita.png



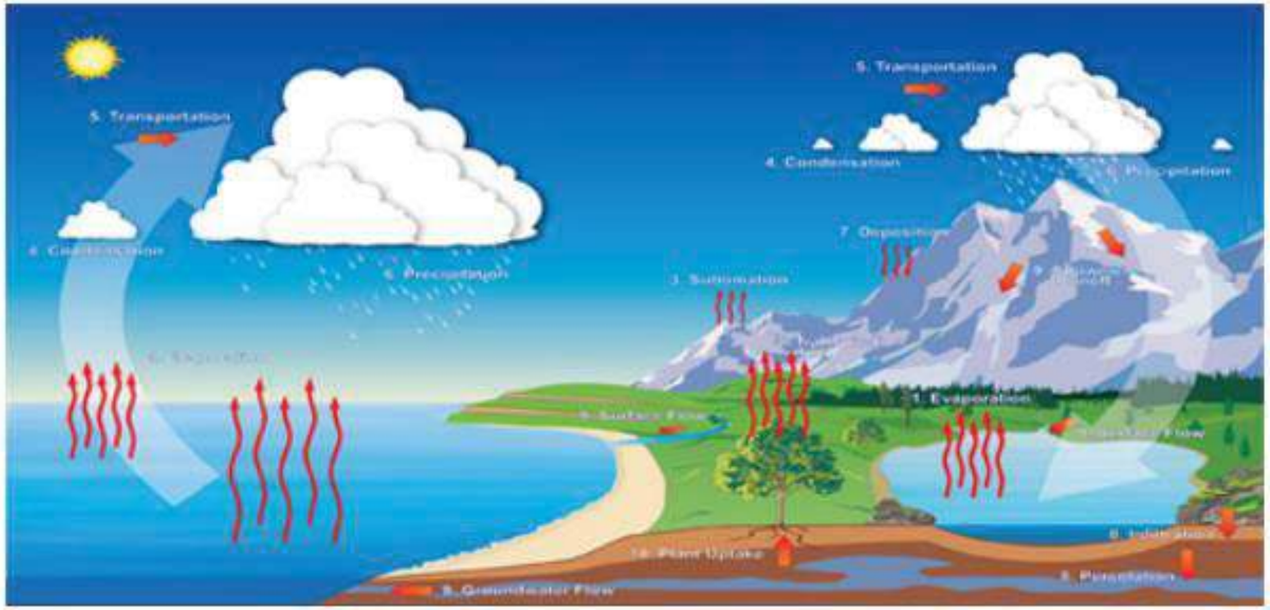
http://ec.europa.eu/eurostat/en/web/products-press-releases/-/8-14032017-BP

Elektri ja soojuse genereerimis- ning salvestussüsteemide hierarhiline jaotus



https://fuelcellsworks.com/news/92-new-hydrogen-refuelling-stations-worldwide-in-2016

Hydrogen Fuel Cost vs Gasoline



Hydrogen... It's Renewable

Cost of Hydrogen[1]

Source: Water

Supply: Infinite

Renewable: Yes

Carbon Footprint: No

Cost per gallon: $1.00 – 1.80kg (gge)

Source cost: $1.50 per 1000/gal. or $0.0015/gallon[2]

Refinery Costs: $700 – $3,500/bpd

Miles per kg of Hydrogen: 81

Additional Environmental Impact Costs: No

Gasoline... It's Non-Renewable

Cost of Gasoline

Source: Crude Oil

Supply: Finite

Renewable: No

Carbon Footprint: Yes

Cost per gallon: $2.32[1]

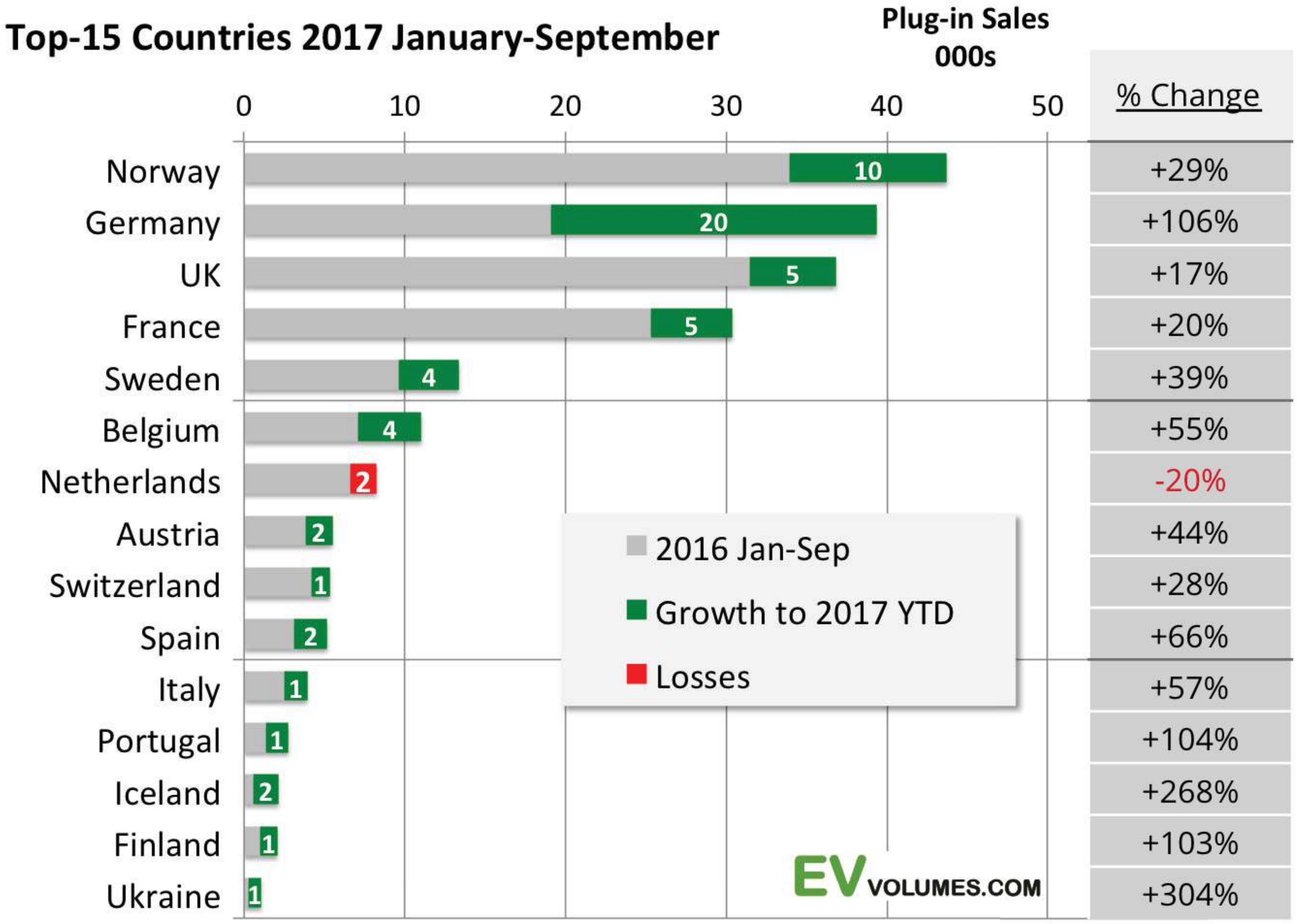
Source Cost: $101.14/barrel[2] or $1.98/gallon

Refinery Costs: $1,000 – $5,000/bpd

Miles per Gallon of Gasoline: 18 – 31

Additional Environmental Impact Costs: Yes

http://h



http://www.ev-volumes.com/

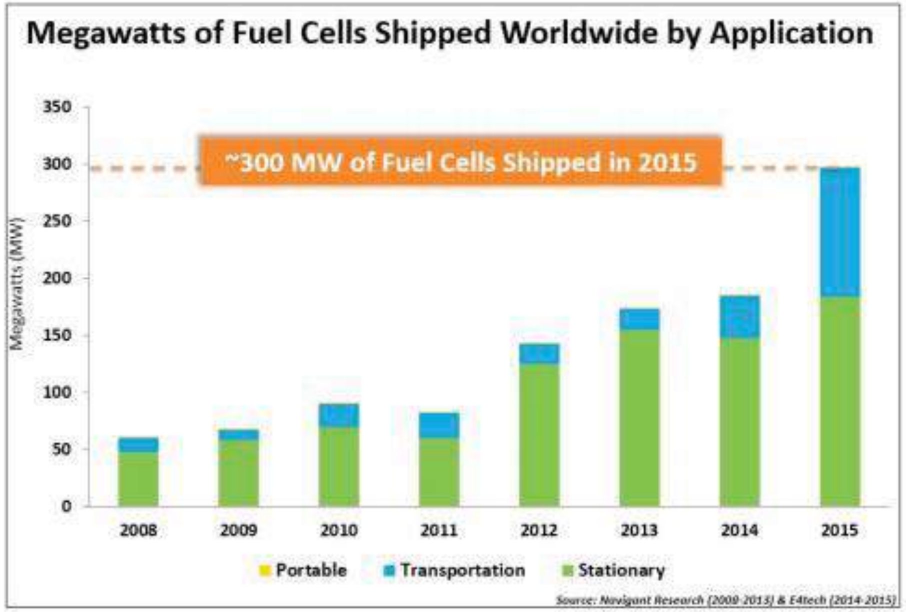


Figure 1. Megawatts of Fuel Cells Shipped in 2015, by Application

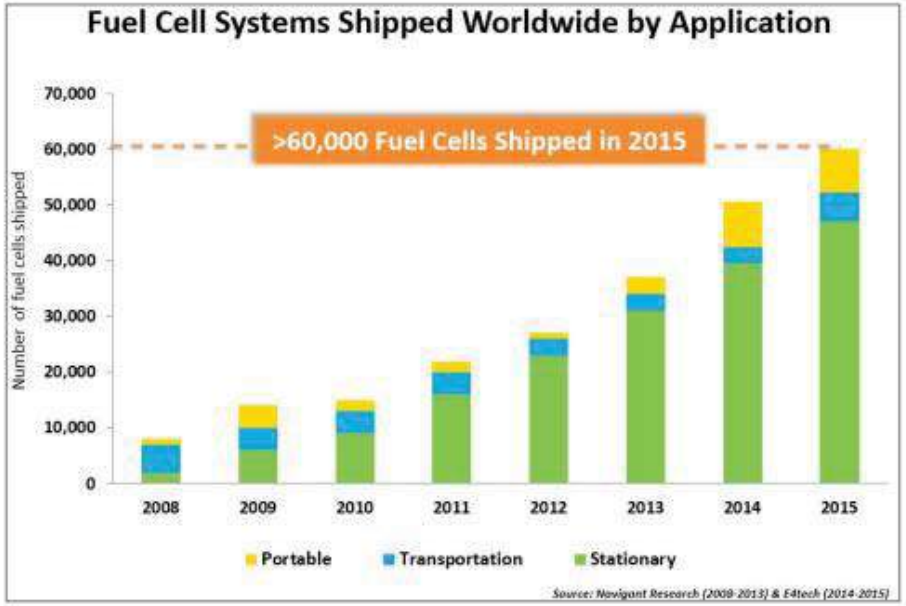


Figure 2. Fuel Cell Systems Shipped Globally, by Application

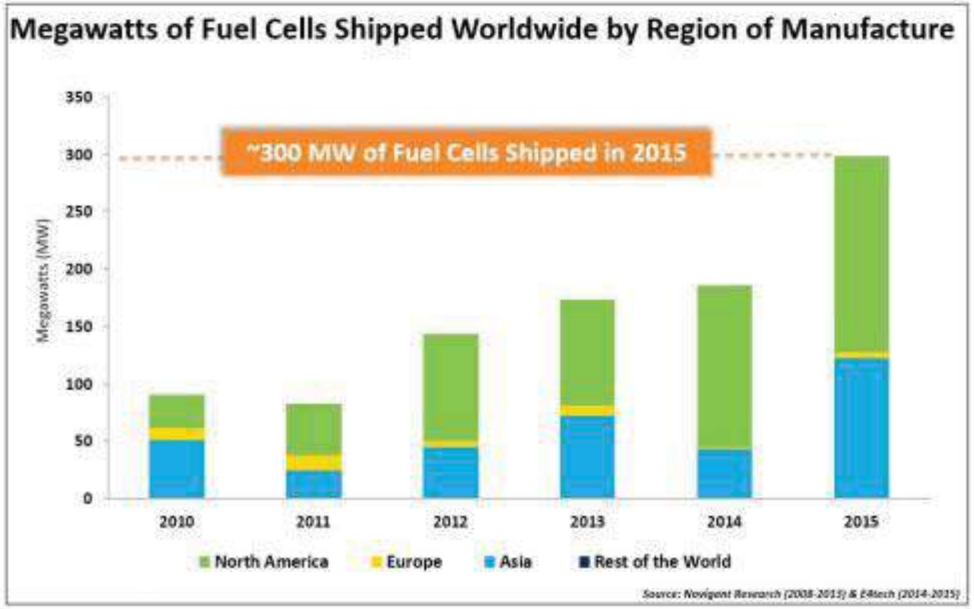
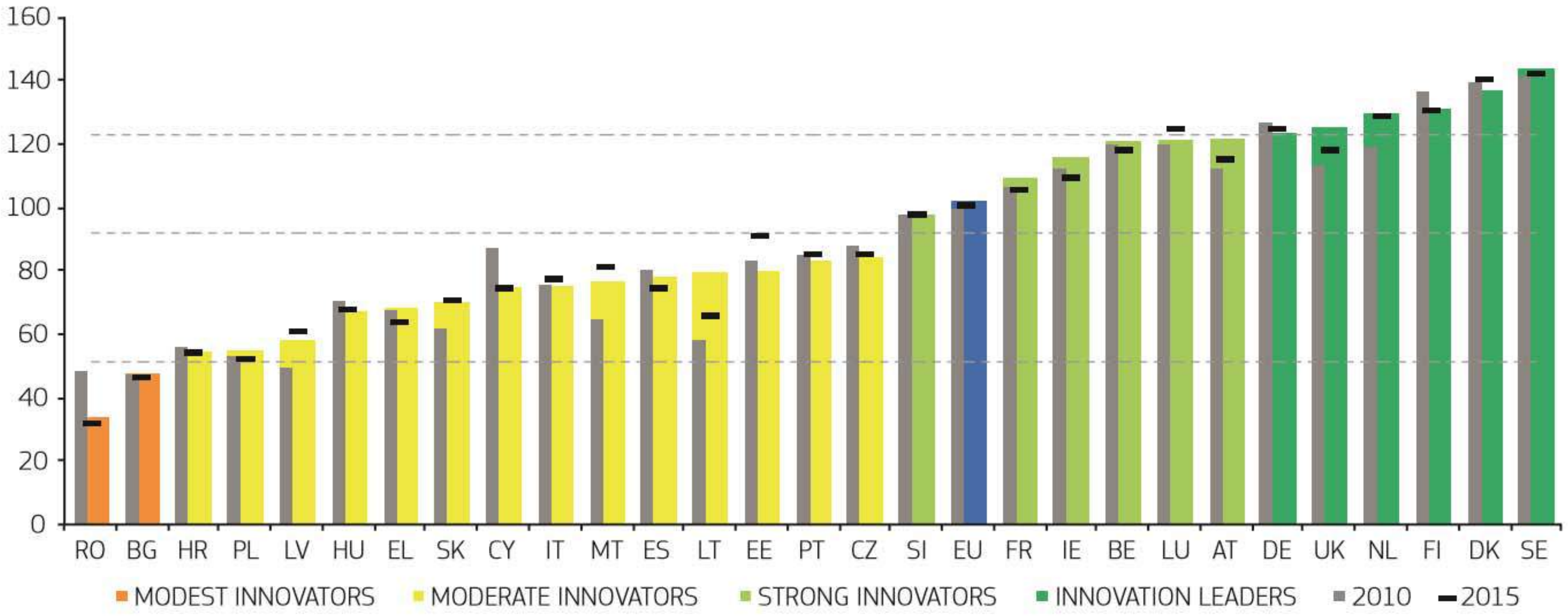


Figure 3. MW of Fuel Cells Shipped Globally, by Region of Manufacture

https://energy.gov/sites/prod/files/2016/10/f33/fcto_2015_market_report.pdf

Figure 1: Performance of EU Member States' innovation systems



Coloured columns show Member States' performance in 2016, using the most recent data for 27 indicators, relative to that of the EU in 2010. The horizontal hyphens show performance in 2015, using the next most recent data for 27 indicators, relative to that of the EU in 2010. Grey columns show Member States' performance in 2010 relative to that of the EU in 2010. For all years the same measurement methodology has been used. The dashed lines show the threshold values between the performance groups in 2016, comparing Member States' performance in 2016 relative to that of the EU in 2016.

European Innovation Scoreboard 2017 (http://ec.europa.eu/DocsRoom/documents/24829)

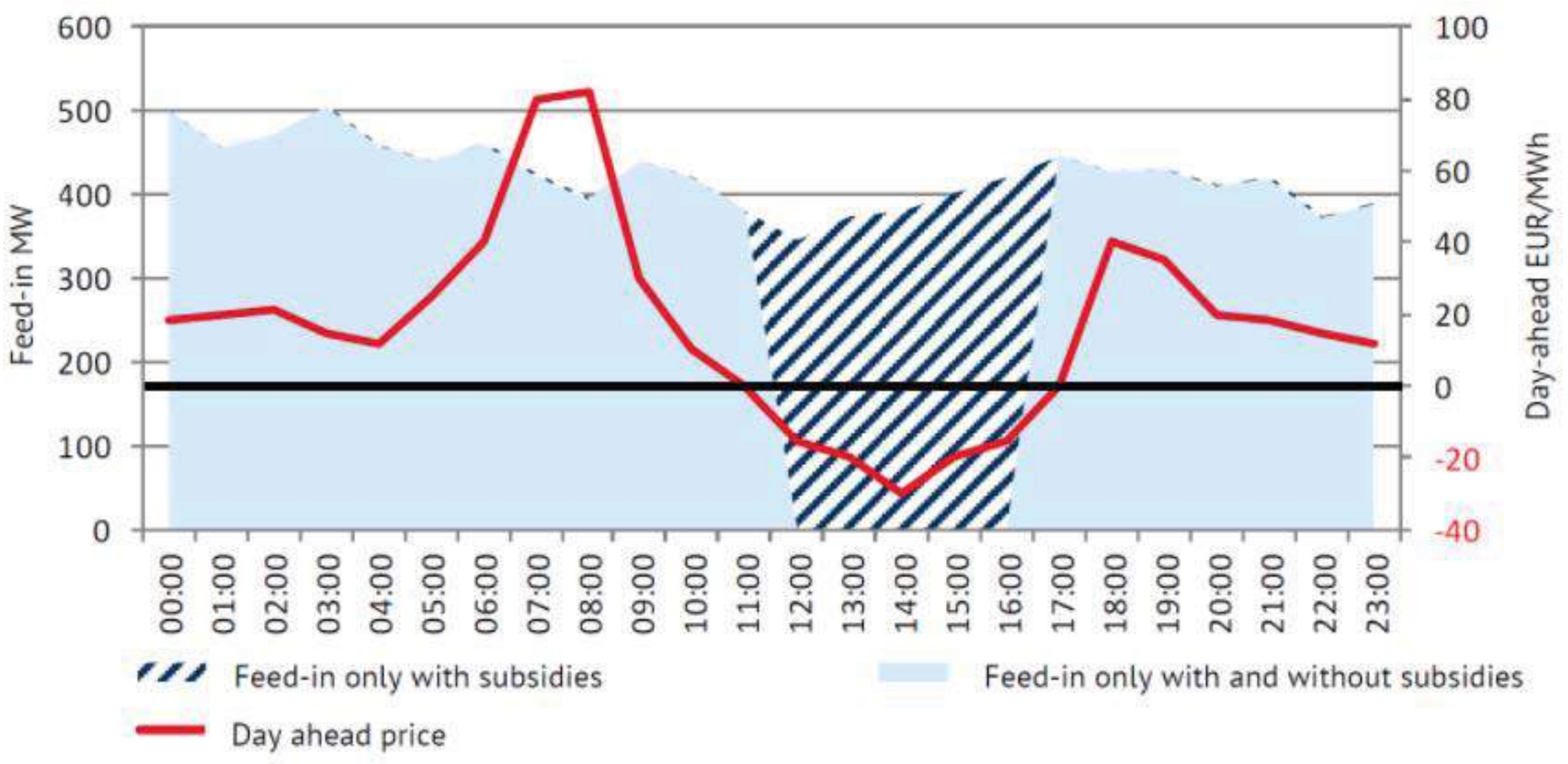
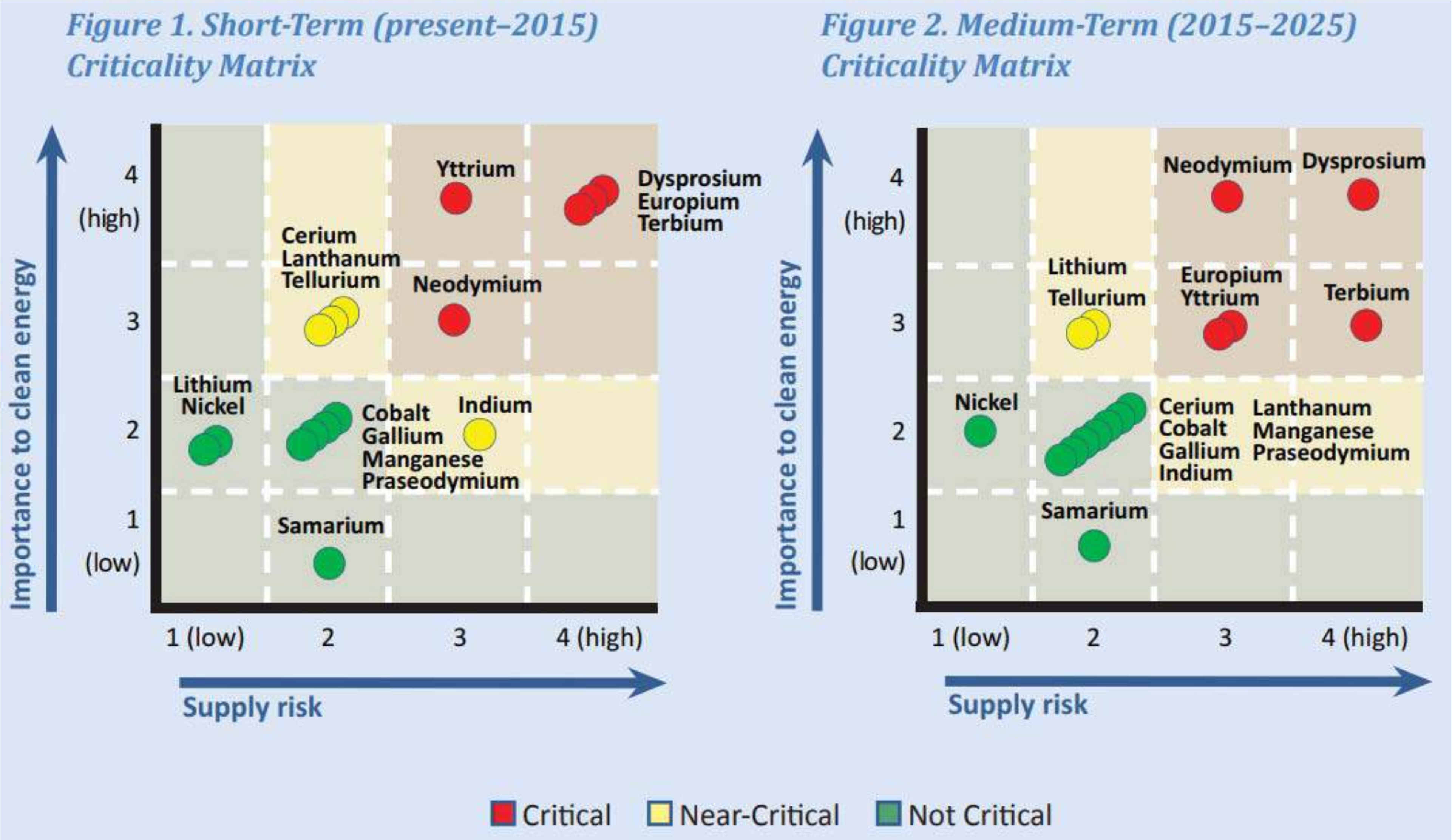


Figure 1: Example of a typical feed-in behaviour of subsidised and non-subsidised fluctuating renewable energies

http://energypost.eu/how-to-calculate-revenues-of-solar-and-wind-power-when-the-subsidies-stop/



https://energy.gov/sites/prod/files/DOE_CMS_2011_Summary.pdf

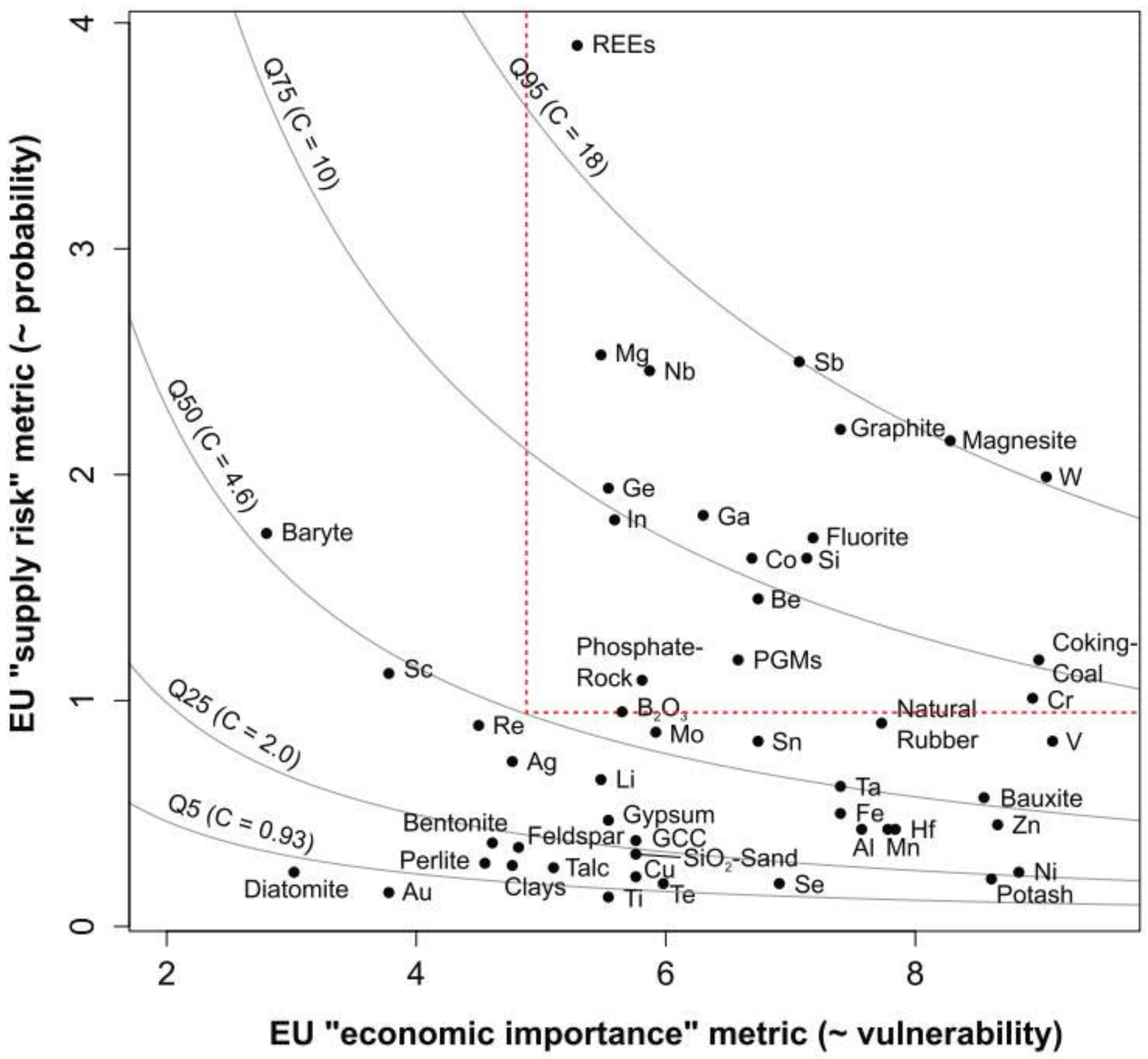
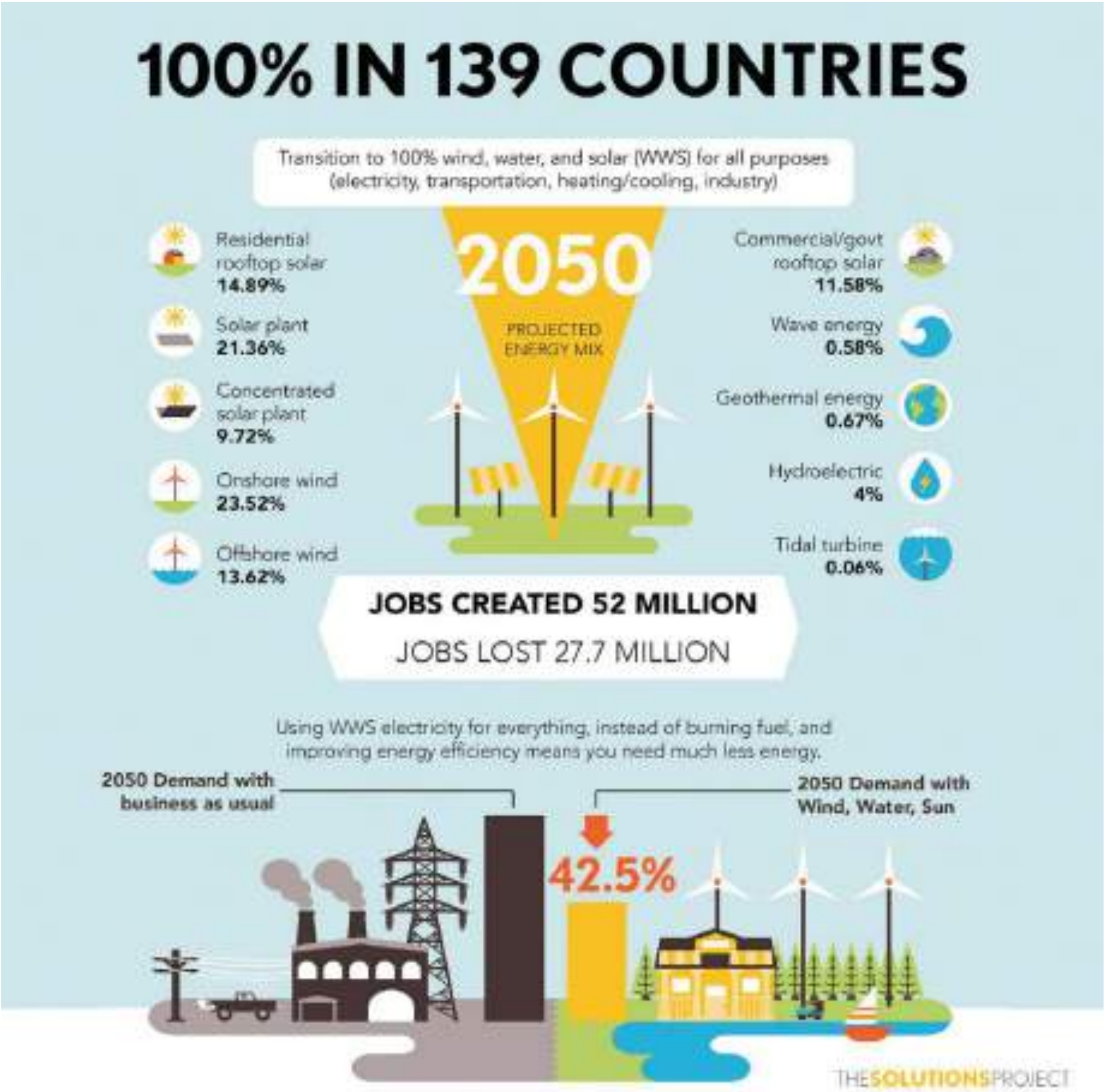


Figure 3. Re-plot of the criticality plot used in the EU study (EU Commission 2014) to identify critical raw materials, showing both the boundary of the criticality field used by the EU (broken line), and contours of constant criticality calculated as the product of the two assessment dimensions (i.e. D * V; grey lines). Contours show the 5th, 25th, 50th, 75th, and 95th quantiles of the distribution of overall criticality scores, as labelled. Plot data from EU Commission (2014), inspired by Glöser *et al* (2015).

M. Frenzel *et al., J. Phys. D: Appl. Phys.* **50** (2017) 123002

100% renewable energy for 139 nations detailed in Stanford report



https://c1cleantechnicacom-wpengine.netdna-ssl.com/files/2017/08/100-renewable-energy-139-countries.png

Tänuavaldused !

This work was supported by the Estonian target research project IUT20-13, the Estonian Centre of Excellence in Science Project TK117T "High-technology Materials for Sustainable Development", the Estonian Energy Technology Program project SLOKT10209T, the Materials Technology project SLOKT12180T.

Tänan tähelepanu eest!

Võimalikud tehnoloogiad energia (elektri) salvestamiseks.

Salvestamis-tehnoloogia	PHS	CAES	Vesinik	Hooratas	SMES	Super-konden-saator (EKKK)	Tavalised patareid		Kõrgtehnoloogilised patareid			Läbivoolu redokspatarei	
							Pb-patarei	NiCd	Li-ioon	NaS	NaNiCl ZEBRA	VRB	ZnBr
Võimsus, MW	100-5000	100-300	0.001-50	0.002-20	0.01-10	0.01-1	0.001-50	0.001-40	0.001-0.1	0.5-50	0.001-1	0.03-7	0.05-2
Energia	1-24h+	1-24h+	s-24h+	15s-15min	ms-5min	ms-1h	s-3h	s-h	min-h	s-hours	Min-h	s-10h	s-10h
Reaktsiooniaeg	s-min	5-15 min	min	s	Ms	ms						ms	ms
Energiatihedus, Wh/kg	0.5-1.5	30-60	800-104	5-130	0.5-5	0.1-15	30-50	40-60	75-250	150-240	125	75	60-80
Võimsustihedus, W/kg			500+	400-1600	500-2000	0.1-10	75-300	150-300	150-315	90-230	130-160		50-150
Töötemperatuur (°C)				-20 - +40		-40- +85				300-350	300	0-40	
Isetühjenemine (%päevas)	~0	~0	0.5-2	20-100	10-15	2-40	0.1-0.3	0.2-0.6	0.1-0.3	20	15	0-10	1
Efektiivsus	75-85	42-54	20-50	85-95	95	85-98	60-95	60-91	85-100	85-90	90	85	70-75
Eluaeg (aastad)	50-100	25-40	5-15	20+	20	20+	3-15	15-20	5-15	10-15	10-14	5-20	5-10
Tsüklid	$2x10^4$-$5x10^4$	$5x10^3$-$2x10^4$	10^3 +	10^5-10^7	10^4	10^4-10^8	100-1000	1000-3000	10^3-10^4+	2000-4500	2500+	10^4+	2000+
Võimsus ehitus hind €/kW	500-3600	400-1150	550-1600	100-300	100-400	100-400	200-650	350-1000	700-3000	700-2000	100-200	2500	500-1800
Energia ehitus - hind €/kW	60-150	10-120	1-15	1000-3500	700-7000	300-4000	50-300	200-1000	200-1800	200-900	70-150	100-1000	100-700

PHS - pumphüdroakumulatsioonijaam
CAES - kokkusurutud õhu salvestid
SMES - ülijuhtivusega magneti magnetväljade energia salvesti

TABLE I. Program and Power System Development Objectives.

Metric	Current Status	2020 Target	2030 Target
System Cost	~$12,000/kWe	$6,000/kWe	$900/kWe
SOFC Power Degradation Rate	~1.0%/1,000h	0.5 – 1.0%/1,000h	0.2%/1,000h
Cell Manufacturing Approach	Batch	Semi-Continuous	Continuous
Demonstration Scale	50 kWe & 200 kWe POC Systems – Intended Initial Operations Completed 400 kWe Prototype System – Design of First System in Process 250 kWe – 500 kWe Prototype Systems Two additional needed	1 – 5 MWe DG, Integrated Systems	10 – 50 MWe Integrated Systems

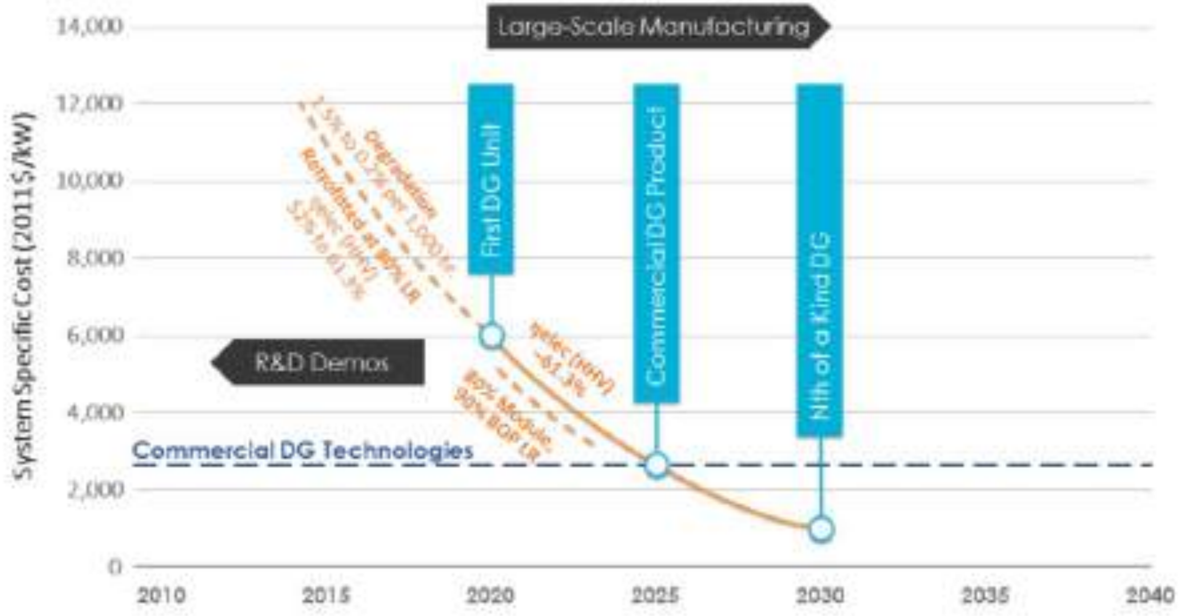
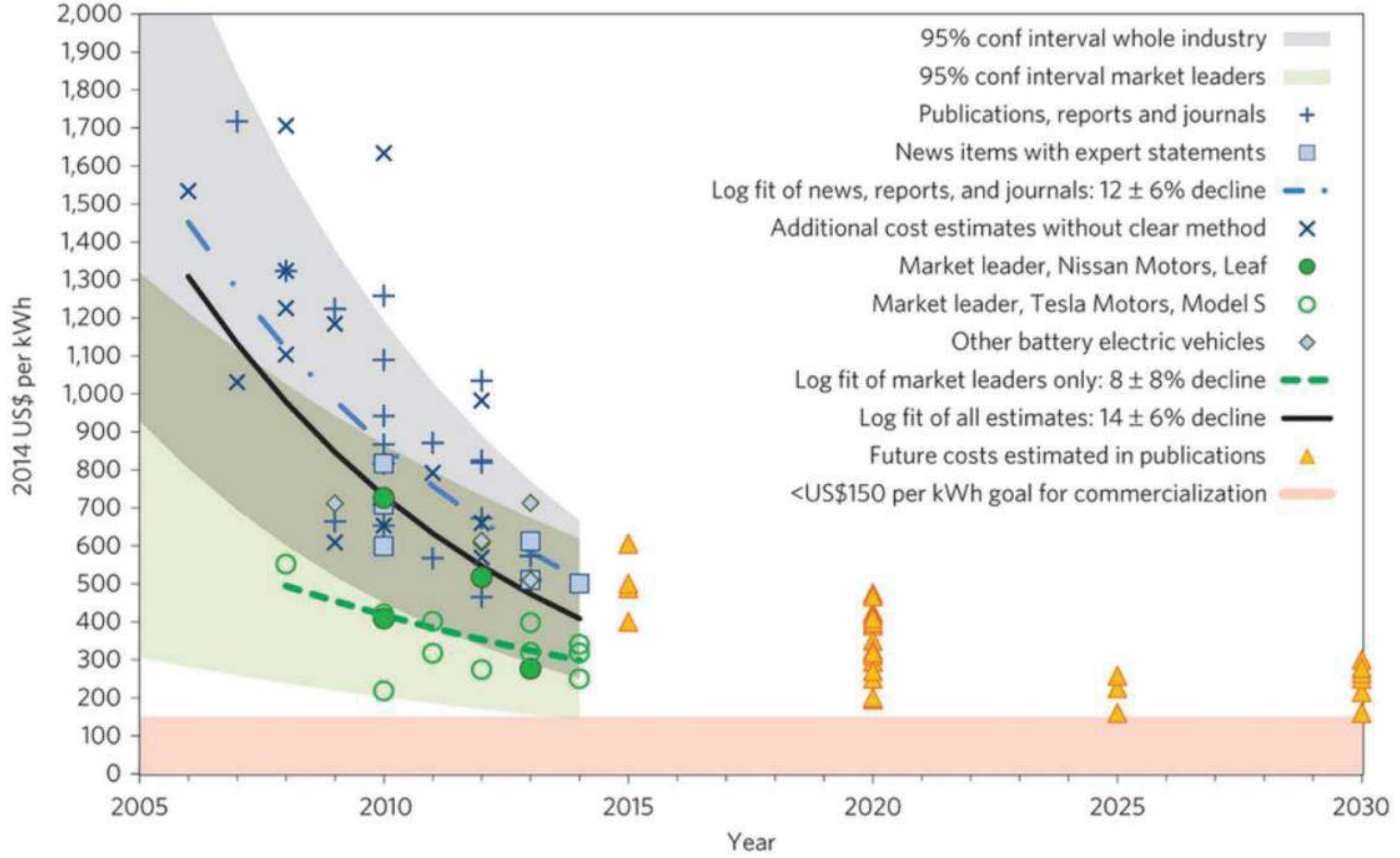


Figure 3. Projected SOFC DG System Cost Reduction via SOFC Program Progress and Large-Scale Manufacturing Implementation.

S.D. Vora et al., ECS Trans. 78 (2017) 3-19



Source: Nature Climate Change 5, 329–332 (2015)

Graph 1. The cost evolution of vehicle batteries.

https://ec.europa.eu/energy/sites/ener/files/documents/swd2017_61_document_travail_service_part1_v6.pdf

	Power-intensive application example (1 h of storage)				Energy-intensive application example (8 hrs of storage)				Long-term storage (2,000 hrs of storage)
	2013		2030		2013		2030		2030
	Low	High	Low	High	Low	High	Low	High	Low
Li-ion	138	573	38	106	181	754	76	218	1,000s
NaS	n/a	n/a	n/a	n/a	196	269	42	68	1,000s
Flow-V	155	238	57	97	148	239	50	96	1,000s
Lead	211	379	59	110	114	262	39	98	1,000s
CAES-A	27	n/a	19	n/a	49	n/a	37	n/a	1,000s
LAES-A	40	82	32	66	71	166	57	133	1,000s
PHES	18	28	18	28	24	42	24	42	>400
P2P H_2	Electrolyser and CCPP with salt cavern storage considered for P2P H_2 – suitable for longer-term storage								140

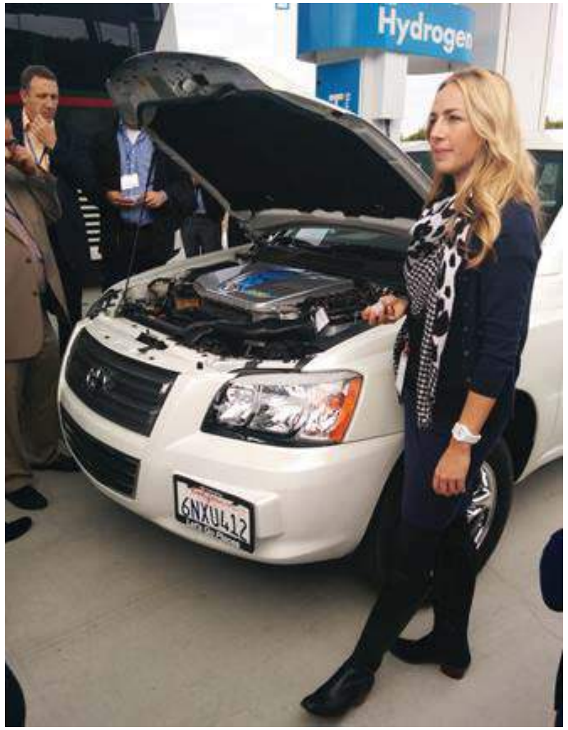
Source: Fuel Cells and Hydrogen Joint Undertaking (2015), Commercialisation of Energy Storage in Europe

Table 1. The levelised cost of electricity storage for different timeframes (€/MWh).

https://ec.europa.eu/energy/sites/ener/files/documents/swd2017_61_document_travail_service_part1_v6.pdf

Fuel cell cars in production

2007 - Honda FCX Clarity - hydrogen fuel cell
2014 - Hyundai ix35 FCEV [2]
2015 - Toyota Mirai - production version of the FCV concept car



https://en.wikipedia.org/wiki/List_of_fuel_cell_vehicles

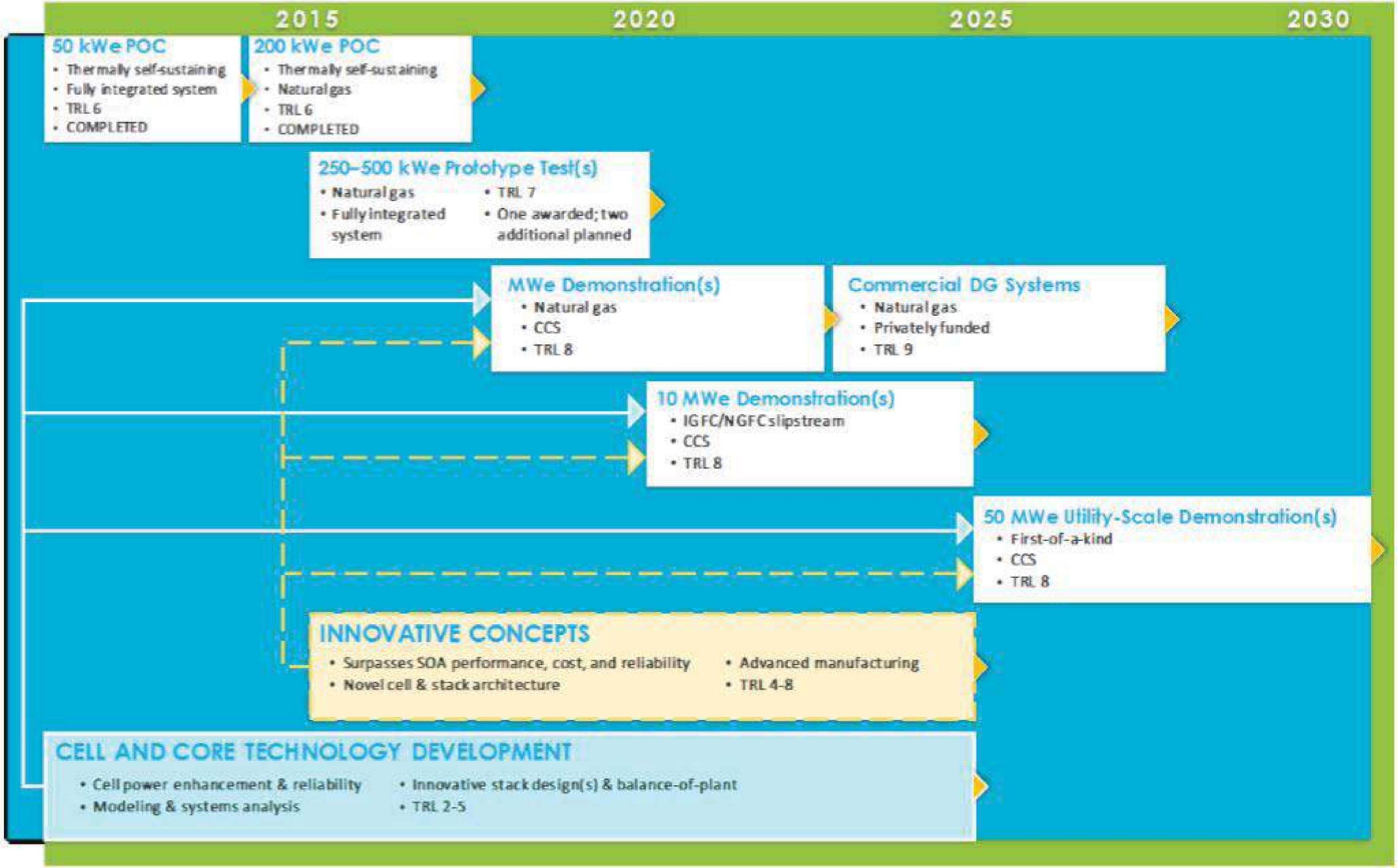
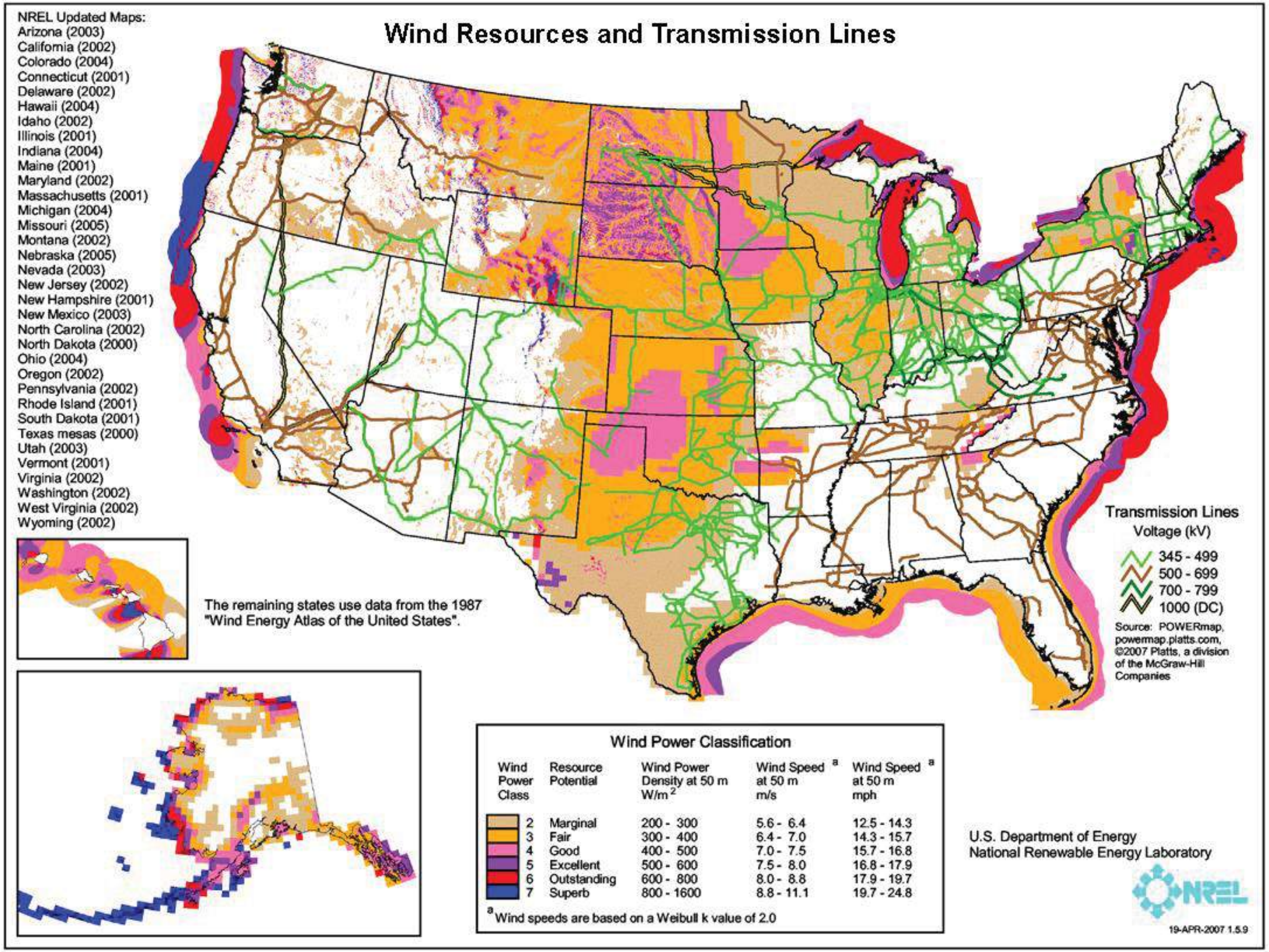


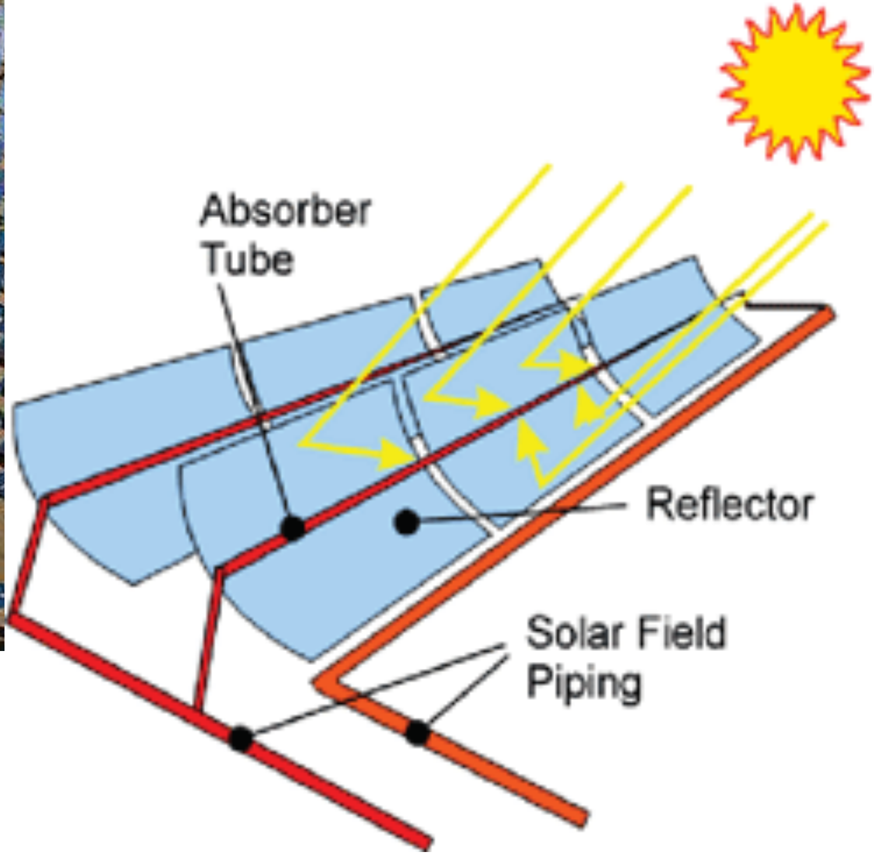
Figure 12. SOFC Program Development Timeline.

S.D. Vora et al., ECS Trans. 78 (2017) 3-19


Wind Resources and Transmission Lines
NREL Updated Maps:
Arizona (2003)
California (2002)
Colorado (2004)
Connecticut (2001)
Delaware (2002)
Hawaii (2004)
Idaho (2002)
Illinois (2001)
Indiana (2004)
Maine (2001)
Maryland (2002)
Massachusetts (2001)
Michigan (2004)
Missouri (2005)
Montana (2002)
Nebraska (2005)
Nevada (2003)
New Jersey (2002)
New Hampshire (2001)
New Mexico (2003)
North Carolina (2002)
North Dakota (2000)
Ohio (2004)
Oregon (2002)
Pennsylvania (2002)
Rhode Island (2001)
South Dakota (2001)
Texas mesas (2000)
Utah (2003)
Vermont (2001)
Virginia (2002)
Washington (2002)
West Virginia (2002)
Wyoming (2002)
The remaining states use data from the 1987 "Wind Energy Atlas of the United States".
Transmission Lines
Voltage (kV)
345 - 499
500 - 699
700 - 799
1000 (DC)
Source: POWERmap, powermap.platts.com, ©2007 Platts, a division of the McGraw-Hill Companies
Wind Power Classification
Wind Power Class
Resource Potential
Wind Power Density at 50 m W/m²
Wind Speed a at 50 m m/s
Wind Speed a at 50 m mph
2 Marginal 200 - 300 5.6 - 6.4 12.5 - 14.3
3 Fair 300 - 400 6.4 - 7.0 14.3 - 15.7
4 Good 400 - 500 7.0 - 7.5 15.7 - 16.8
5 Excellent 500 - 600 7.5 - 8.0 16.8 - 17.9
6 Outstanding 600 - 800 8.0 - 8.8 17.9 - 19.7
7 Superb 800 - 1600 8.8 - 11.1 19.7 - 24.8
a Wind speeds are based on a Weibull k value of 2.0
U.S. Department of Energy
National Renewable Energy Laboratory
19-APR-2007 1.5.9

Peegelväljad päikeseenergia kogumiseks

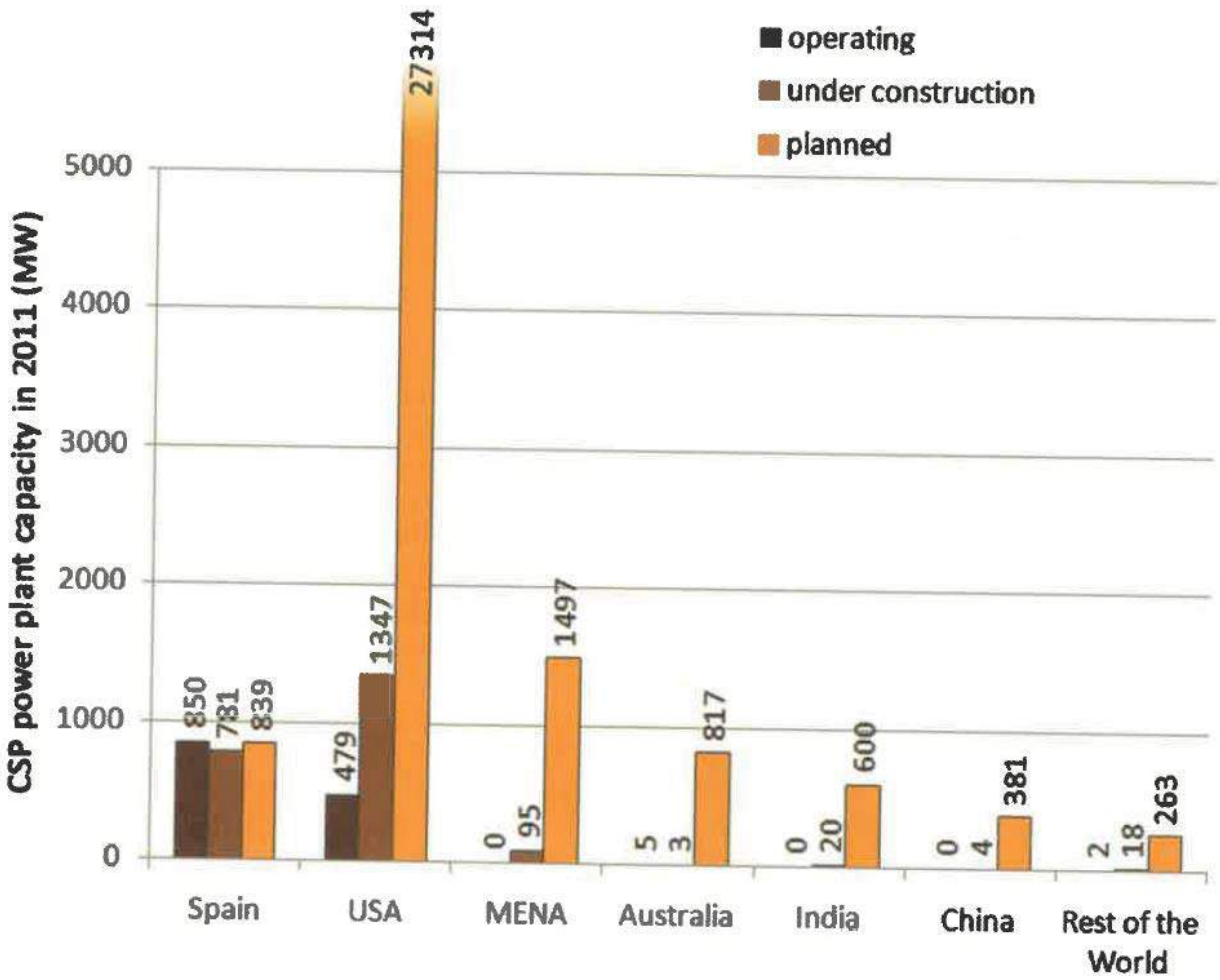
Kõrgtemperatuursed protsessid



Vee kuumutamine

J. Johnson, C&EN, October 20, 2008, p. 40; Arisoona kõrbes,üldpindala

Figure 7.1 Worldwide distribution of CSP plants that are operational, under construction and planned.

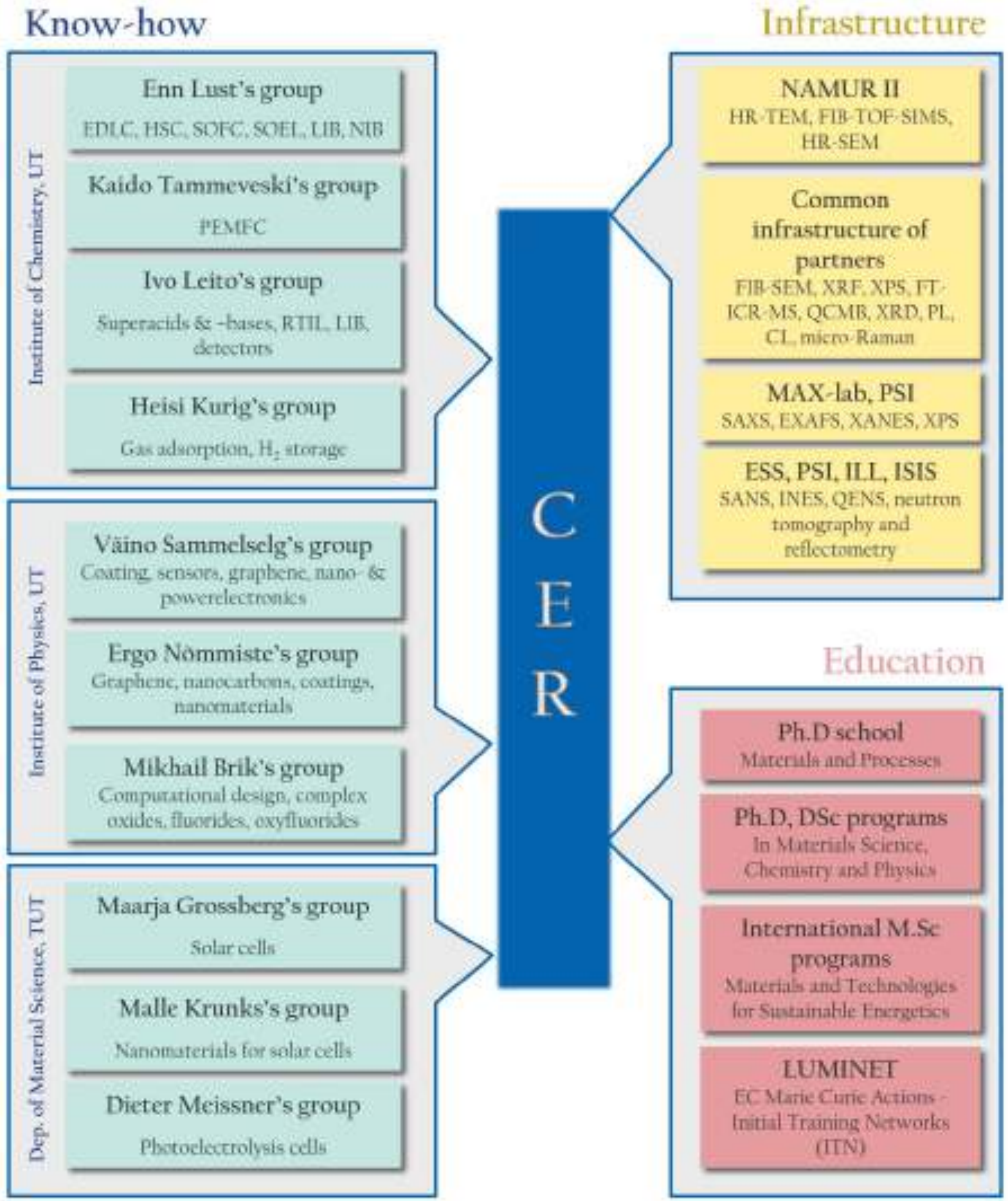


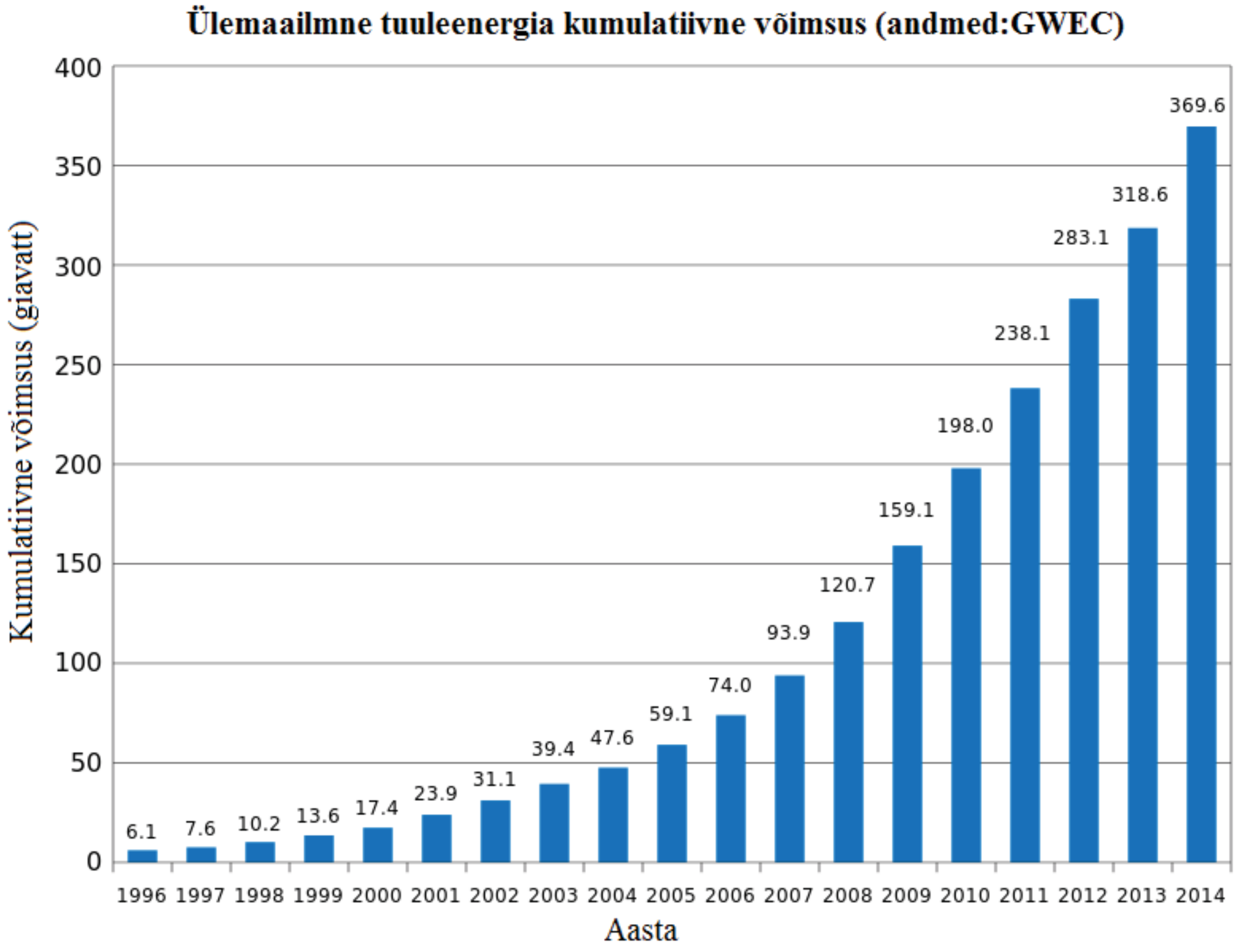
Concentrating solar power: its potential contribution to a sustainable energy future, EASAC policity report. 16, Nov. 2011, p. 35

Scheme of The Centre of Excellence

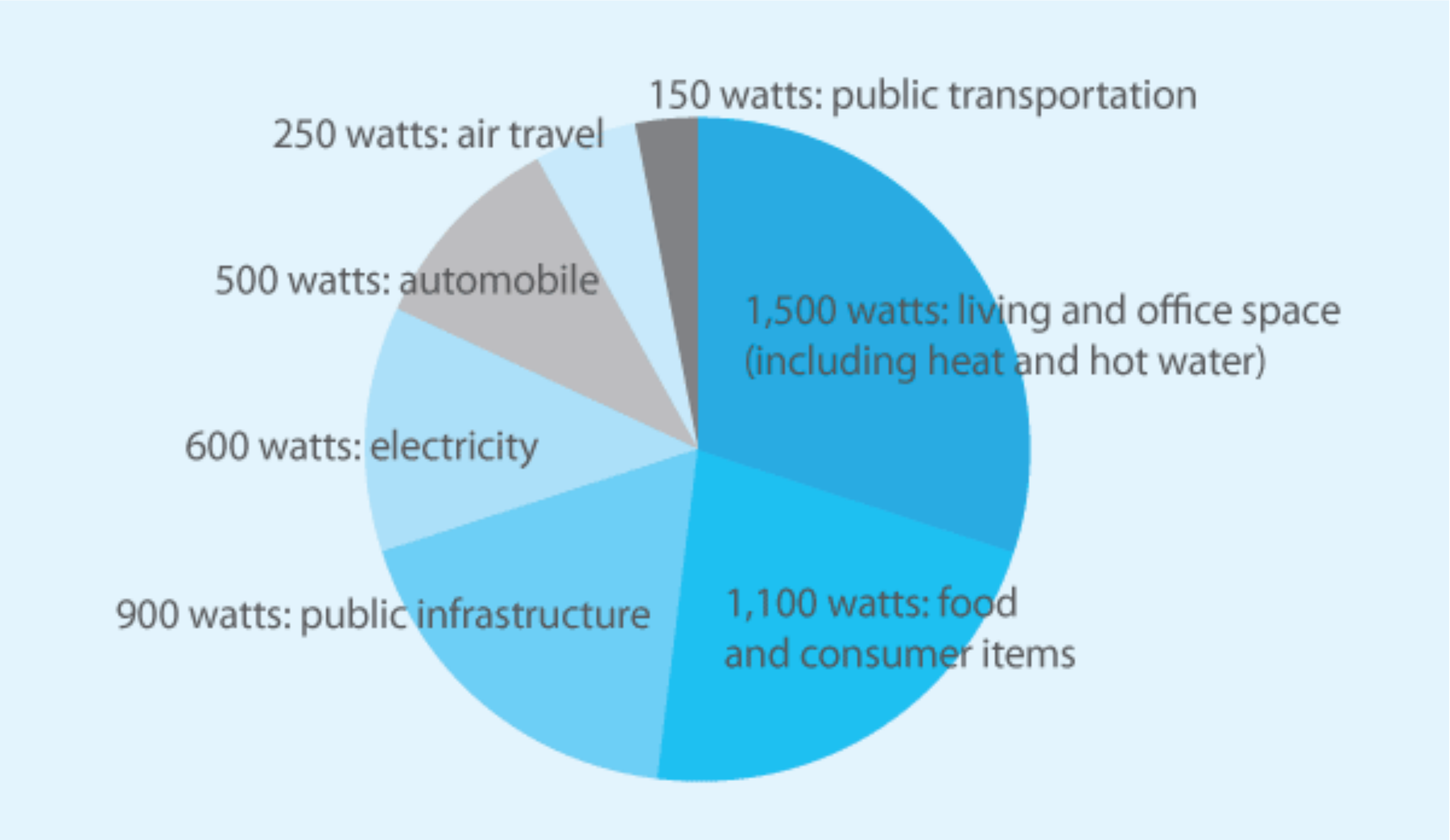
„Advanced materials and high-technology devices for energy recuperation systems“

PI Enn Lust

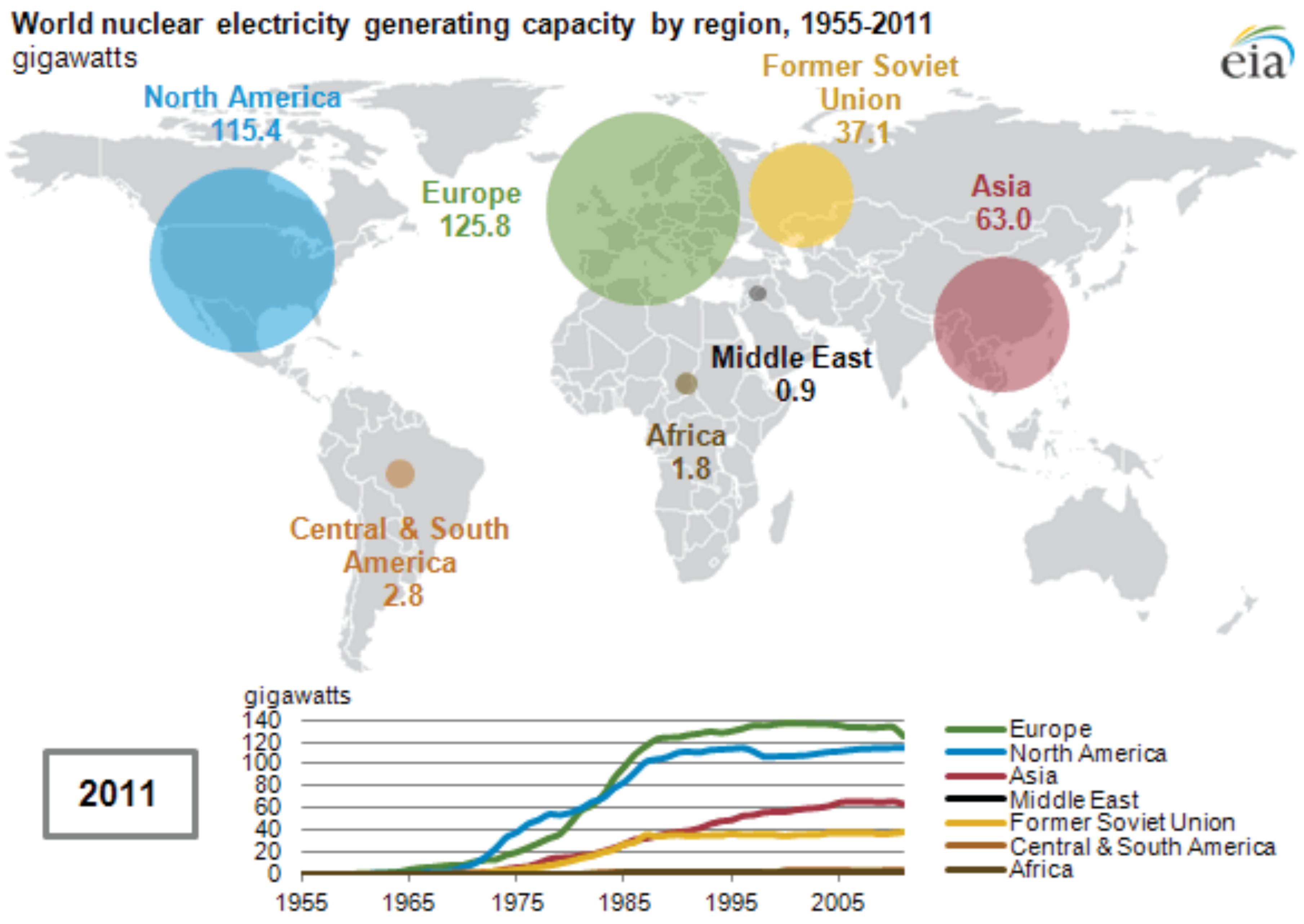



Ülemaailmne tuuleenergia kumulatiivne võimsus (andmed:GWEC)
Kumulatiivne võimsus (giavatt)
Aasta
0
50
100
150
200
250
300
350
400
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
6.1
7.6
10.2
13.6
17.4
23.9
31.1
39.4
47.6
59.1
74.0
93.9
120.7
159.1
198.0
238.1
283.1
318.6
369.6

Breakdown of total watts currently used by the average Swiss (5,000 W)



https://i.unu.edu/media/ourworld.unu.edu-en/article/786/breakdown-watts.gif



http://www.akbizmag.com/Alaska-Business-Monthly/May-2012/Global-generation-capacity-for-nuclear-power-has-grown-to-over-346-gigawatts-since-1955/

Rahvusvaheline Energiaagentuur kui energiainnovatsiooni mootor

2. November 2017

Peter Gornischeff
Nõunik OECD ja IEA juures
peter.gornischeff@mfa.ee

MAJANDUS- JA KOMMUNIKATSIOONIMINISTEERIUM

Proloog

Hiroaki Kitano, President and CEO of Sony Computer Science Laboratories, Japan

MAJANDUS- JA KOMMUNIKATSIOONIMINISTEERIUM

Mis on IEA (ja OECD)?

OECD innovatsioonipoliitika

https://www.innovationpolicyplatform.org

OECD teaduspoliitika töögrupp

Kuidas kasutada big datat paremini teadusetegemises?

Maaülevaated ja võrdlused.

Majandus- ja Kommunikatsiooniministeerium

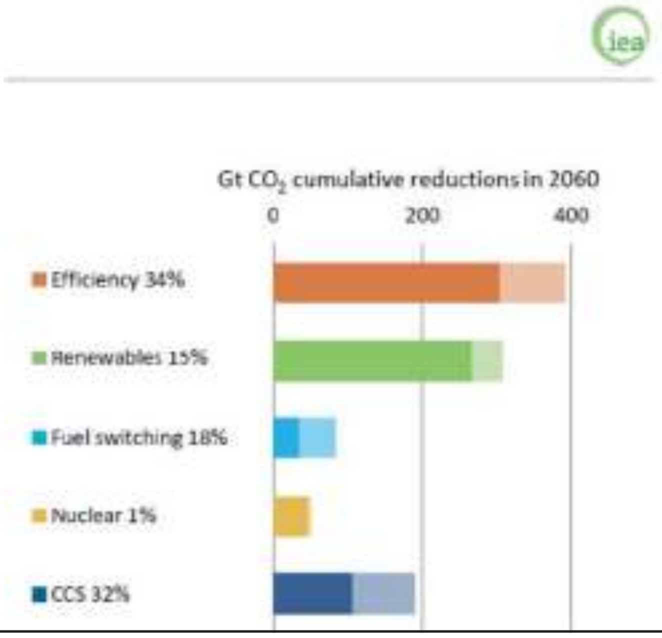
OECD GOING DIGITAL PROJEKT

Majandus- ja Kommunikatsiooniministeerium

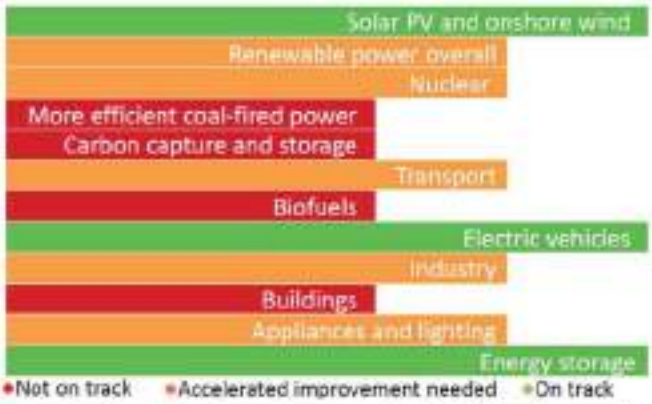
IEA agenda/lisaväärtus

- ENERGIAJULGEOLEK
- Mis toimub energeetikamaastikul laiemalt (energiatehnoloogia, puhas energia, vedelkütuseturg). **Tracking technology gaps v.t tabel järgmisel slaidil.**
- COP21
- Võimalus võrrelda liikmesriikide vahel poliitikaid
- Väljaanded

MAJANDUS- JA KOMMUNIKATSIOONIMINISTEERIUM



How are we doing?



Tracking Clean Energy Progress (*TCEP*) highlights the overall status and recent progress of clean-energy technologies as well as providing insights to achieve their full potential

TRACKING TECHNOLOGY GAPS

OECD/IEA 2017

TCP expertise and global network

- **38 TCPs, five groups:**
  - Cross-cutting activities (2)
  - End use and energy efficiency (14)
  - Fossil fuels (5)
  - Fusion power (8)
  - Renewable energy and hydrogen (9)

TCP / IEA inter-relations:
- *34 TCPs input into IEA analysis / modelling*
- *30 TCPs at IEA events / workshops*
- *23 TCPs in third-party events with the IEA*

OECD/IEA 2017

Bioenergia tehnoloogiakoostöö programm

www.ieabioenergy.com

MAJANDUS- JA KOMMUNIKATSIOONI-MINISTEERIUM

Biomass

- **Health impact of combustion aerosols from biomass**
- **Study of the future thermal biomass plants in RE-based grid**

MAJANDUS- JA KOMMUNIKATSIOONI-MINISTEERIUM

Gasification of biomass and waste

- Vaatavad *feeding*ut ja *carbon capture*'it. Kõrvalproduktide väärtustamise küsimused.
- Metaani emissiooni raport.
- Põhisõnum: **kui olla ebatäpne, siis biogaasi raporteid võidakse kasutada „meie enda vastu“.** Üks põhiküsimus on, kuidas viia transpordisüsteem biokütuste peale nii, et see oleks jätkusuutlik.

MAJANDUS- JA KOMMUNIKATSIOONIMINISTEERIUM

Biogas

- Taanil on plaan asendada kogu tarvitatav gaas biomassi gaasiga (märkuseks 2015 oli Taani sisse imporditavast biomassist 40% Venemaalt).

MAJANDUS- JA KOMMUNIKATSIOONIMINISTEERIUM

Climate change Effects of Biomass and Bioenergy Systems

- Biokütused merenduses ja veonduses.
- **Advanced Fuels in Advanced Engines Report**

MAJANDUS- JA KOMMUNIKATSIOONIMINISTEERIUM

Sustainable wood pellet industry

- **Sustainable wood pellet industry and trade study**
- Vaatavad ühtlasi, mis on mõju hindadele.

MAJANDUS- JA KOMMUNIKATSIOONIMINISTEERIUM

Biorefineries

- *Strategic biorefineries development.*
- **Joint bioeconomy report and survey 2017**

Majandus- ja Kommunikatsiooniministeerium

Biomass feedstocks for energy markets

- *Exploring novel regional landscape approaches to govern bioenergy supply chain developments.*

Majandus- ja Kommunikatsiooniministeerium

CCS ja CCUS

- *Bio-CCS and forestry* (Jussi Manninen, VTT).
- **Ilma antud küsimuse lahendamiseta ei saavuta bioenergiaga COP21 eesmärke!**

MAJANDUS- JA KOMMUNIKATSIOONI-MINISTEERIUM

Biomass supply chains and sustainability

- Uurivad, milline peaks olema optimaalseim n.ö *settlement.*
- Rohkem infot: www.Ign.ku.dk/bioenergy-conf-ao18/

MAJANDUS- JA KOMMUNIKATSIOONI-MINISTEERIUM

Energia valdkonna TA&I rahastamine 2018-2020 tööprogrammis

Mari Habicht
Eesti Teadusagentuur

TEUK Tartus 2.11.2017

Horisont 2020 struktuur

Tipptasemel teadus

- Euroopa Teadusnõukogu (ERC)
- Tulevased ja kujunemisjärgus tehnoloogiad
- Marie Skladowska-Curie nimelised meetmed
- Teadustaristu

Juhtpositsioon tööstuses

- IKT
- Nanotehnoloogia
- Materjalitehnoloogia
- Biotehnoloogia
- Arenenud tootmis- ja töötlemistehnoloogia
- Kosmosetehnoloogia
- Riskikapitali kättesaadavuse tagamine
- Innovatsioon VKEedes

Ühiskonnaprobleemid

- Tervishoid ja heaolu
- Toiduga kindlustatus, säästev põllumajandus, mere- ja merendusuuringud ning biomajandus
- Energia
- Transport
- Kliimameetmed
- Ühiskond
- Turvalisus

Laienemine. Teadus ja ühiskond. Sotsiaal- ja humanitaarteadused. IKT

Euroopa Innovatsiooniinstituut (EIT)

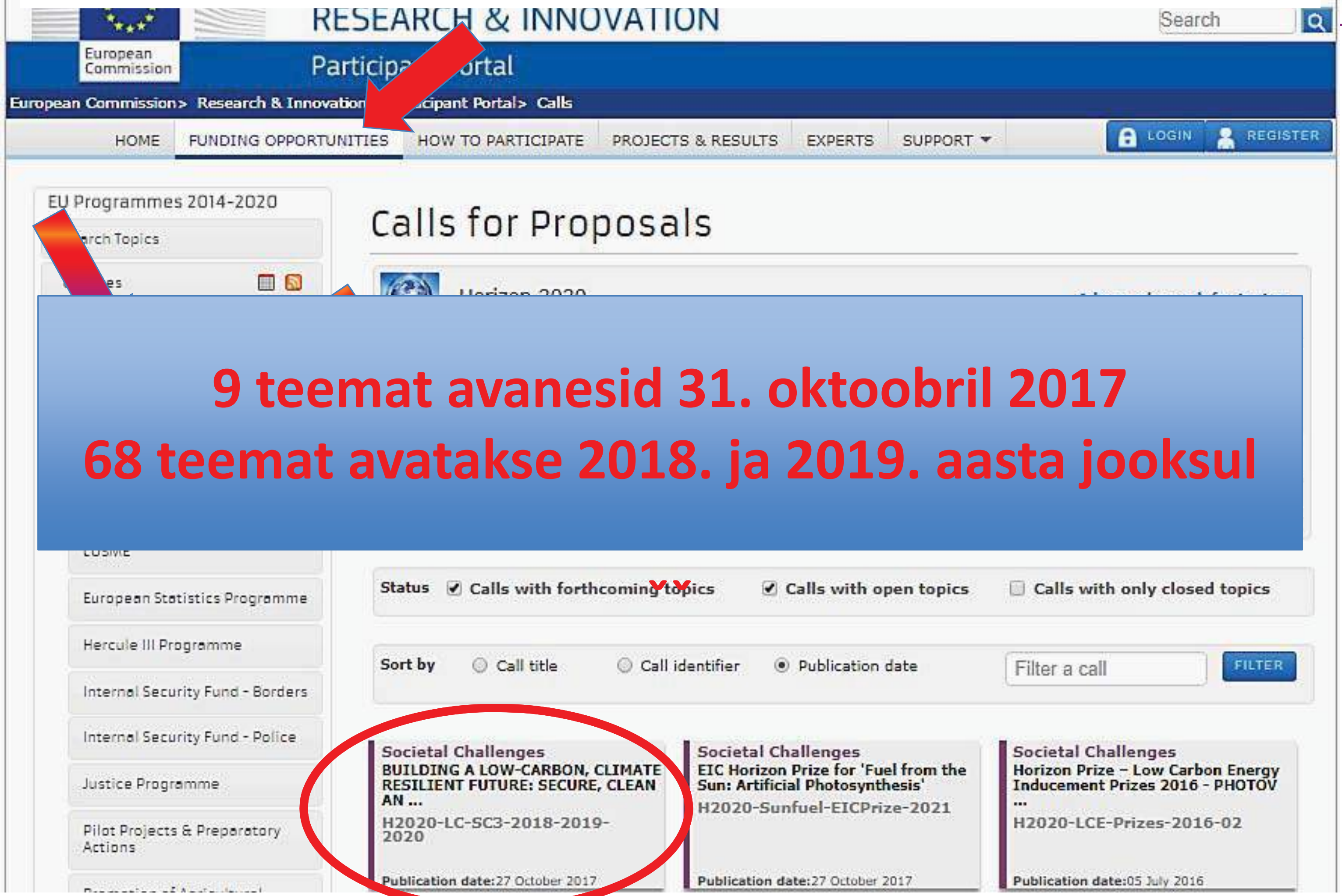
EURATOM

Euroopa Ühisuuringute keskus (JRC)

Olulised teemad:

- Energiatarbimise ja CO_2 jalajälje vähendamine aruka ja säästva kasutamise abil;
- Varustamine odava, vähese CO_2 heitega toodetud elektriga;
- Alternatiivsed kütused ja mobiilsed energiaallikad;
- Ühtne arukas Euroopa elektrivõrk;
- Uued teadmised ja uus tehnoloogia;
- Põhjendatud otsustamine ja üldsuse kaasamine;
- Energiauuenduste turuletoomine
- Energiajulgeolek ja tarnekindlus
- Taaskasutus, korduvkasutus, jäätmete ringlusse toomine

http://ec.europa.eu/research/participants/portal/desktop/en/home.html



9 teemat avanesid 31. oktoobril 2017

68 teemat avatakse 2018. ja 2019. aasta jooksul

Kaheksa konkurssi

1. Energiatõhusus – EE
2. Globaalne juhtroll taastuvenergia al
3. Nutikas ja puhas energia tarbi
4. Nutikad tarbijakesksed – ES
5. Targad linnad ja k
6. Ligi-null tas vutamine fossiilseid kütuse jaamades ja saastavates tö – NZE
7. – JA
8. dadevahelised teemad – CC

Mu tegevused – hanked, auhinnad, grandid

Madala süsinikuheitega, kliimamuutustele vastupidava tuleviku loomine

Lähtepunkt:

- Mis on minu tugevus/konkurentsieelis?
- Mis mul pakkuda on?
- Mida ma vajan?
- Kas ma olen huvitatud rahvusvahelisest koostööst?
- Kas mul on selleks aja- ja inimressurssi?
- Milline on minu teadus-/arendusvõimekus?
- Millist rolli ma endale projektis näen:
  - ✓ Projekti algataja/koordinaator
  - ✓ Vastutava rolliga partner
  - ✓ Konkreetsete ülesannetega partner
  - ✓ Allhanke pakkuja

Võimalikud projektid (1):

- Energiatõhususe meetmed hoonetes
- Ehitussektori arendamine
- Energiatarbimise juhtimine ja töö tarbijatega
- Taastuvenergia tehnoloogiad kaugkütte ja -jahutussüsteemides
- Uue põlvkonna taastuvenergia tehnoloogiad
- Arenduste turulejõudmise kiirendamine
- Uudsed tuule- ja päikeseenergia lahendused
- Elamutesse ja tööstushoonetesse integreeritavad lahendused
- Erinevad lahendused energiatootmise omahinna alandamiseks
- Valdkondliku tööstuse konkurentsivõime suurendamine

Võimalikud projektid (2):

- Erinevad teemad nii ülekande- kui jaotusvõrgu operaatoritele
- Energiasüsteemi paidlikkuse suurendamine ja keskkonnamõjude vähendamine
- Erinevate teenuste arendamine
- Uue põlvkonna biokütuste ja alternatiivsete kütuste arendamine erinevate transpordiliikide jaoks
- Fossiilsetel kütustel töötavate jõujaamade ja saastavate ettevõtete keskkonnamõjude vähendamine, erinevad süsiniku sidumise ja salvestamise tehnoloogiad
- Osalemine Euroopa Komisjoni poolt korraldatavates (innovatsiooni)hangetes

Oluline muutus 2018-2020 tööprogrammis:

Fookusvaldkonnad – hõlmavad kõiki horisondi valdkondi:

- Madala süsinikdioksiidi heitega, kliimamuutustele vastupidava tuleviku ehitamine
- Euroopa tööstuse ja teenuste digiteerimine ning ümberkujundamine
- Majandusliku ja keskkonnaalase kasu ühendamine - ringmajandus
- Julgeolekuliidu mõju suurendamine

* Ühe-, kahe- ja kolmeaastased teemad

* Detailne kirjeldus ja eelarve kahe esimese aasta teemadele

* Enne 2020. aasta konkursse vaadatakse tööprogramm üle ja täiendatakse vastavalt eelmiste aastate tulemustele

Teadusagentuur
ian Research Council

Avamine	Teemad	Tähtaeg
31.10.2017	• Teadustegevuse ühise kavandamise ettevalmistamine • Taastuvenergia tehnoloogiate hinna alandamine ja efektiivsuse tõstmine (2-astmeline, täistaotlus 23.08.2018) • Hoonetesse integreeritavad taastuvenergia süsteemid	31.01.2018
	• Tõhusad taastuvenergia tehnoloogiad koostootmises • Taastuvatest energiaallikatest elektri tootmise hinna oluline alandamine • Uue põlvkonna biokütused ja alternatiivsete kütuste tehnoloogiade arendamine maanteetranspordi jaoks • Uute lahenduste turulejõudmise toetamine • Tõhusamad tehnoloogiad kohalikes kütte- ja jahutuslahendustes • Võimalused hoonetesse integreeritud PV lahenduste oluliseks hinna alandamiseks	13.02.2018

https://www.b2match.eu/energycall2018

Eesti Teadusagentuur
Estonian Research Council

Eesti Teadusagentuur
Estonian Research Council

http://www.c-energy2020.eu/

Eesti Teadusagentuur
Estonian Research Council

Küsimused ja ettepanekud saatke palun:

maria.habicht@etag.ee

Kiired küsimused:
51 74 058

Eesti Teadusagentuur
Estonian Research Council

NUTIKAS
toob teaduse ettevõtte teenistusse

Mida pakume?

- Rahalist tuge oma idee elluviimiseks teadmiste, oskuste ja seadmete abil, mida ettevõttel ei ole, aga mis on olemas teadusasutustes.
- Eelduseks on projekti sobituvus kasvuvaldkondadesse: energeetika puhul IKT ja/või ressursside efektiivsem kasutamine.
- Meetme kogumaht: 26,5 milj eurot, sellest vabu vahendeid ca 20 milj eurot.
- Seni on toetatud 21 projekti, taotluste edukuse määr 42%.

Eesti Teadusagentuur
Estonian Research Council

Mida silmas pidada?

- Toetust jagab SA Archimedes koostöös Eesti Teadusagentuuriga;
- Taotleja: **Eesti äriregistrisse** kantud ettevõte;
- Toetuse suurus: 20 000 – 2 000 000 eurot projekti kohta;
- Toetuse määr: 25% - 70% projekti maksumusest sõltuvalt ettevõtte suurusest ja projekti tüübist;
- Vähemalt 80% projekti kuludest teadusasutusele;
- Kuni 20 % projekti kuludest ettevõttele.

Eesti Teadusagentuur
Estonian Research Council

Kes on tuge saanud?

- **Kerogen OÜ**
  Põlevkivi väärindamine.
- **Crystalsol OÜ**
  Päikesepatareide ökonoomsemaks muutmine.
- **Hepta Group Energy OÜ**
  Õhuliinide õhuseire täiustamine.
- Kõik toetatud projektid

Kes toetab?

Tea Tassa, SA Archimedes, meetmehoidja

tea.tassa@archimedes.ee, 7300396

Viktor Muuli, SA Eesti Teadusagentuur, valdkonnajuht

viktor.muuli@etag.ee, 7300325

Vaata lisa:

- www.archimedes.ee/nutikas
- www.etag.ee/nutikas

Päikeseenergeetika ja innovatsioon

Andres Meesak
Eesti Päikeseelektri Assotsiatsioon

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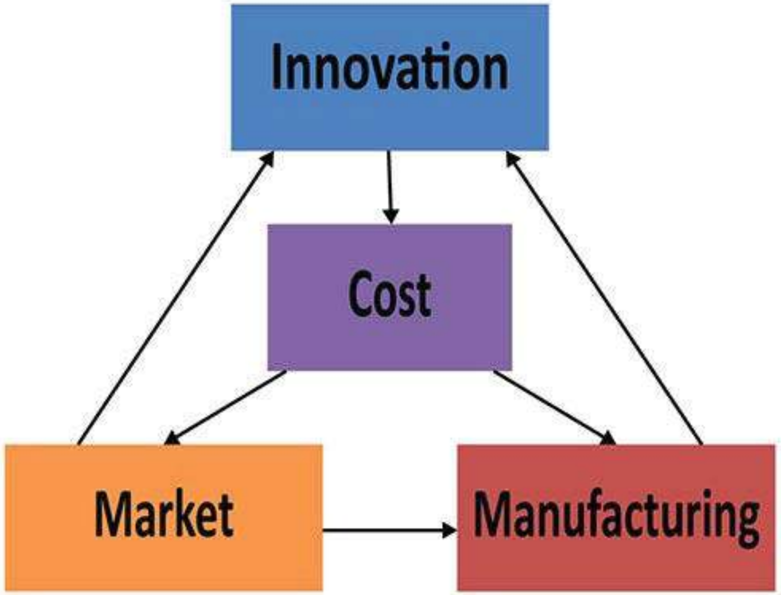
INNOVATSIOON…

… on protsess mis tõlgib idee või leiutise kasulikku tootesse või teenusesse, mis loob väärtust ja mille eest on kliendid nõus maksma.

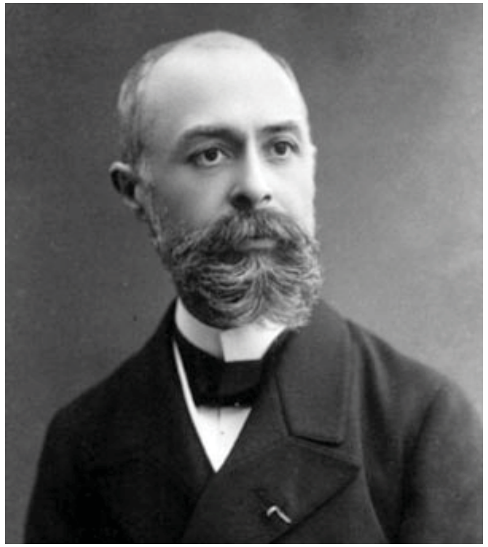
Innovaatiline idee peab olema majanduslikult tasuvalt korratav ja peab rahuldama mingit spetsiifilist vajadust.

Innovatsioon hõlmab teabe, kujutlusvõime ja initsiatiivi tahtlikku rakendamist, et saada ressurssidest suuremaid või erinevaid väärtusi, ning see hõlmab kõiki protsesse, mille abil uusi ideid luuakse ja muudetakse kasulikeks toodeteks

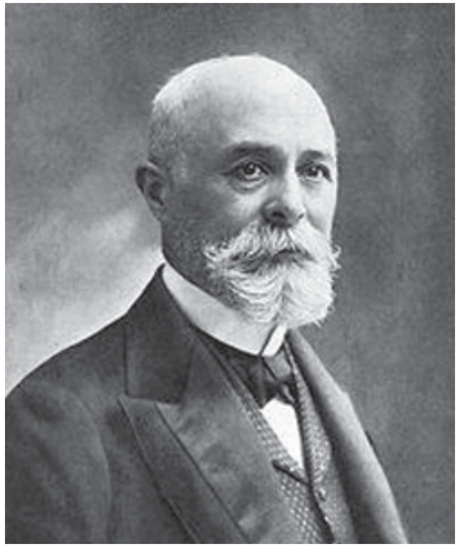
Innovatsioon iseenesest ei tekita turgu!



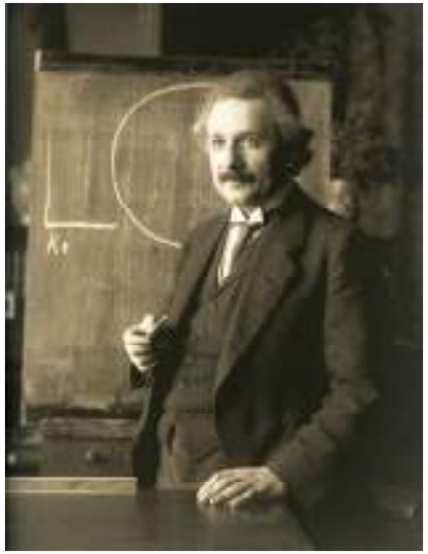
Päikeseenergia rakendamine on lugu innovatsioonist



Alexandre Edmond Becquerel



Charles Edgar Fritts



Albert Einstein

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"I'd put my money on the sun and solar energy. What a source of power! I hope we don't have to wait until oil and coal run out before we tackle that."

Thomas A. Edison, 1931

Päikeseenergia rakendamine on lugu innovatsioonist

1954 Bell Labs

1958 NASA Vanguard 1

1963 Sharp 242W PV-jaam

1966 1kW jaam NASA

80-dad laiatarbe väikeseadmed

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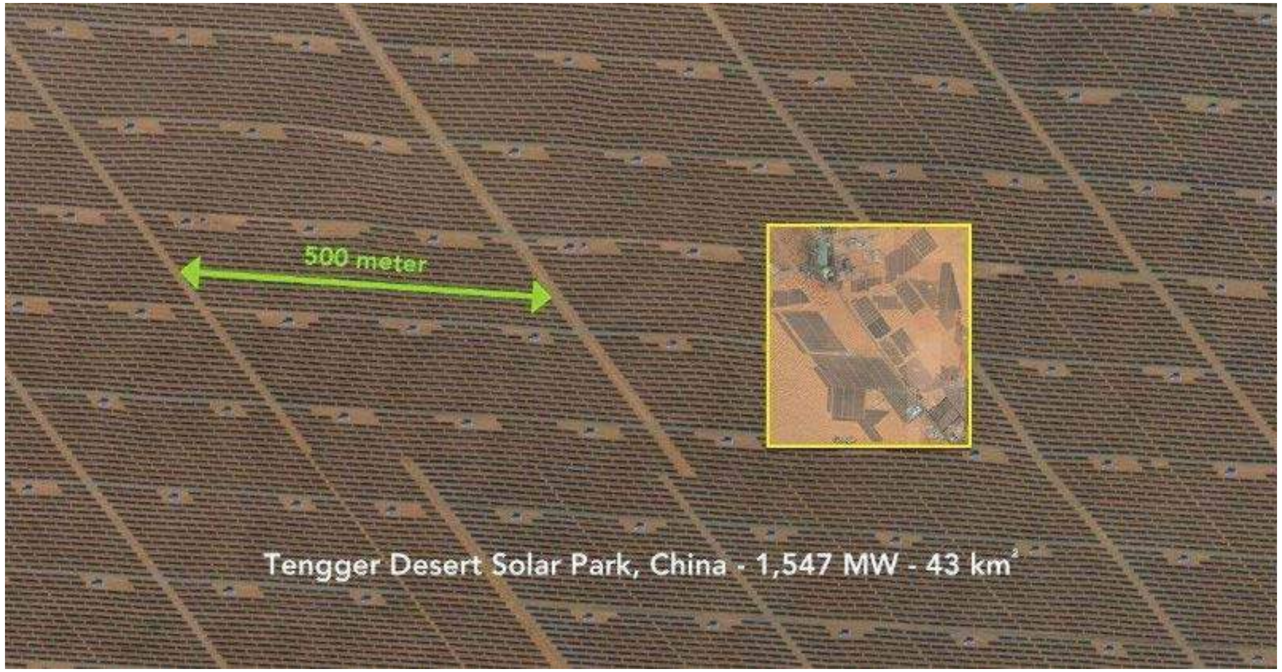
Päikeseenergia rakendamine on lugu innovatsioonist



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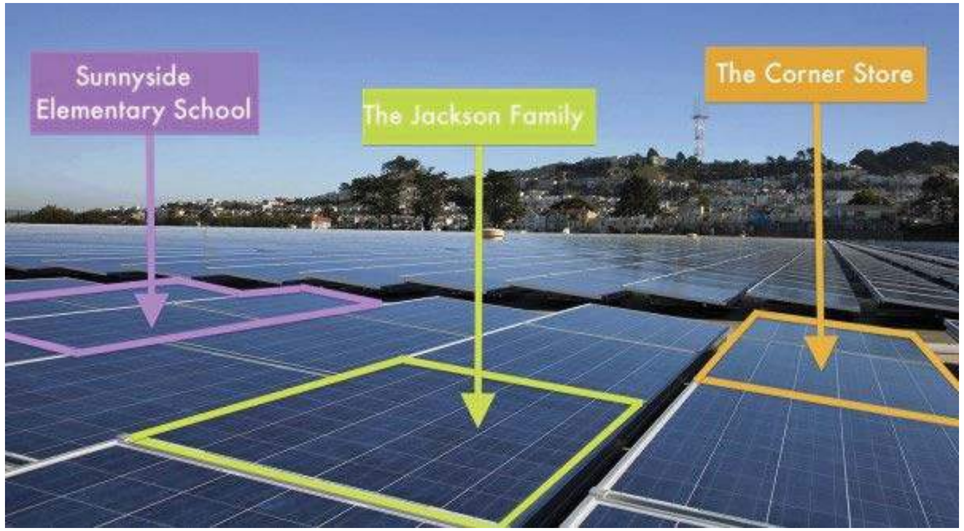
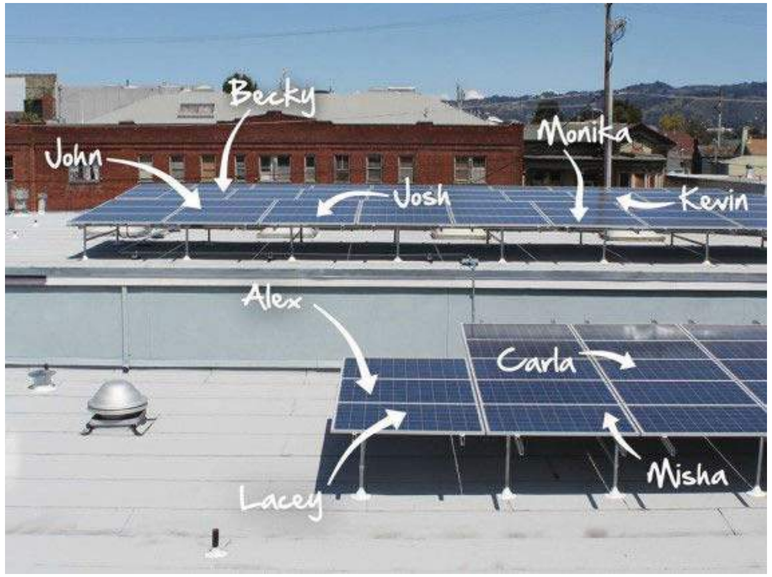
Tehnoloogiline innovatsioon ja ärimudeli innovatsioon



- Kogukondlik ja ühistuline tootmine
- ühisrahastus
- Sotsiaalsed projektid



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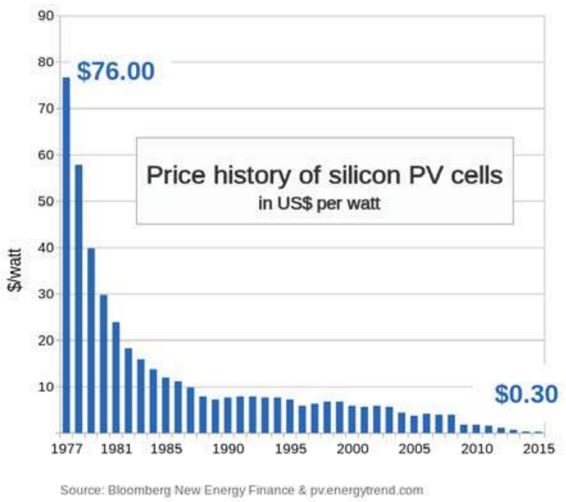
Tehnoloogiline innovatsioon

EPEA



Ärimudelite innovatsioon

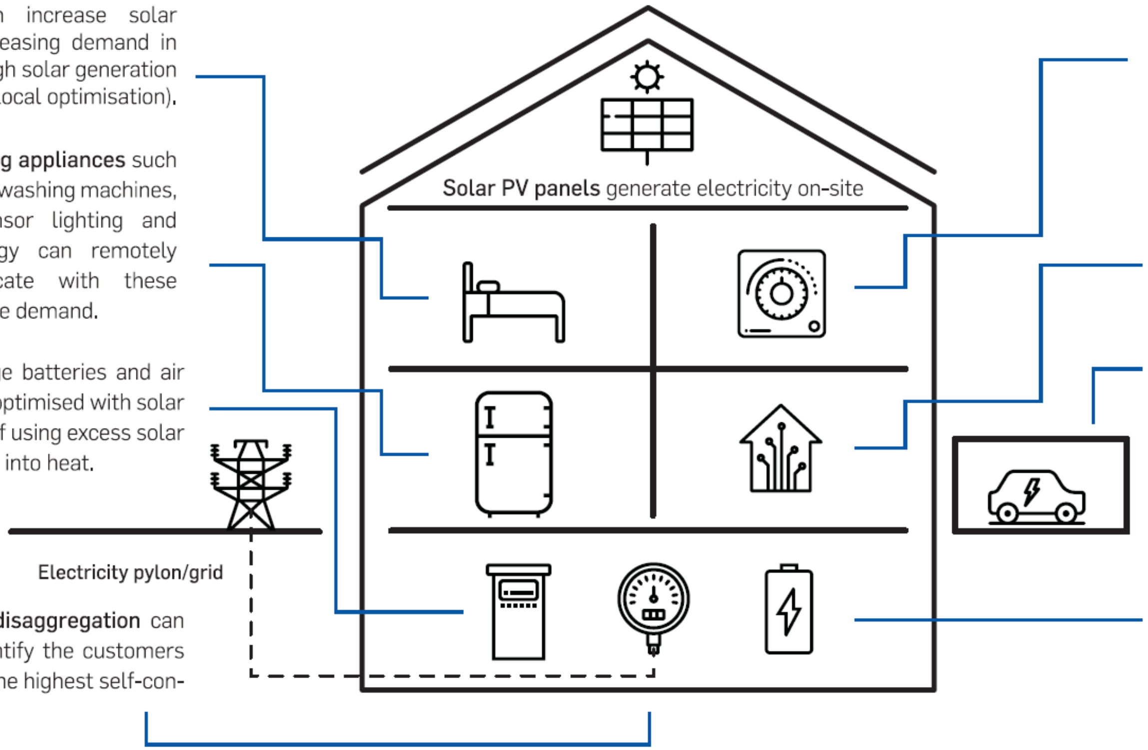
SolarPower Europe

THE SMART BULDING PACKAGE

Demand response can increase solar self-consumption by increasing demand in the building at times of high solar generation and vice versa (known as local optimisation).

Smart automated building appliances such as fridges, tumble dryers, washing machines, dishwashers, motion-sensor lighting and blinds. Digital technology can remotely control and communicate with these appliances to adapt on-site demand.

Heat pumps, heat storage batteries and air conditioning units can be optimised with solar generation and be a way of using excess solar electricity by converting it into heat.



Smart meter data and disaggregation can also be used to help identify the customers that are likeliest to have the highest self-consumption rates.

Smart learning thermostats that are internet connected can be combined with electric heating or cooling. Solar providers in the US are already offering customers free smart thermostats.

Smart building energy management systems which can also provide monitoring, are made possible with wireless communications, advanced data analytics and the Internet of Things.

Smart electric vehicle charging in car parks and the PV4EV 'drive on sunshine' solution could significantly increase self-consumption rates for some households and businesses, especially when combined with storage.

Battery storage is a mutually reinforcing technology when combined with PV. Residential storage can increase solar PV self-consumption rates from approximately 30% to 70% with added system benefits of reducing network and system costs.

Päikeseaknad

EPEA


Päikeseaknad võivad tuleviks teoreetilis
katta pea kogu hoonetes vajata
elektrienerg
Hetkel on tehnoloogia veel väheefektiivne –
kõigest ca. 5% kasuteguriga võrreldes
tavapaneelide 15-18% kasuteguriga, kuid
potentsiaal on jõuda kristallräni paneelidega
võrreldava kasuteguri ja hinnani..

Isetasuvad (kergliiklus)teed

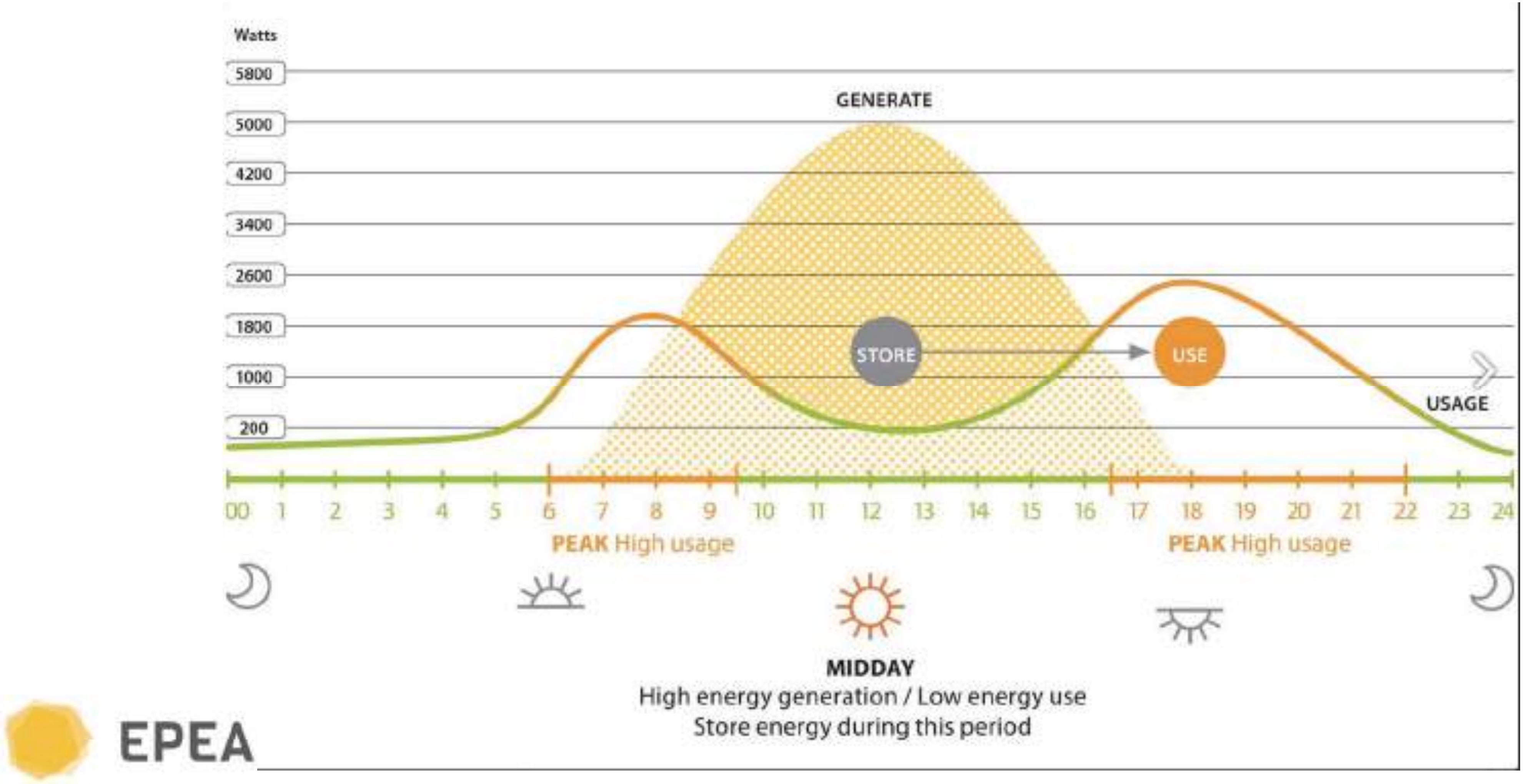
Solaroad kergliiklustee P-Hollandis 2014

- Pikkus 70m
- Ehitajaks Hollandi ettevõte Solaroad
- Pool tavalise betoonkattega ja pool PV-kattega
- 1. aasta toodang LOODETI ligi 10 000 kWh, katab 3 keskmise Hollandi majapidamise aastase elektritarbe, TEGELIK 3000 kWh/a
- Tulevikus ennustatakse selliste teede tasuvusajaks 15 aastat

WATTWAY sõidutee Prantsusmaal 2016

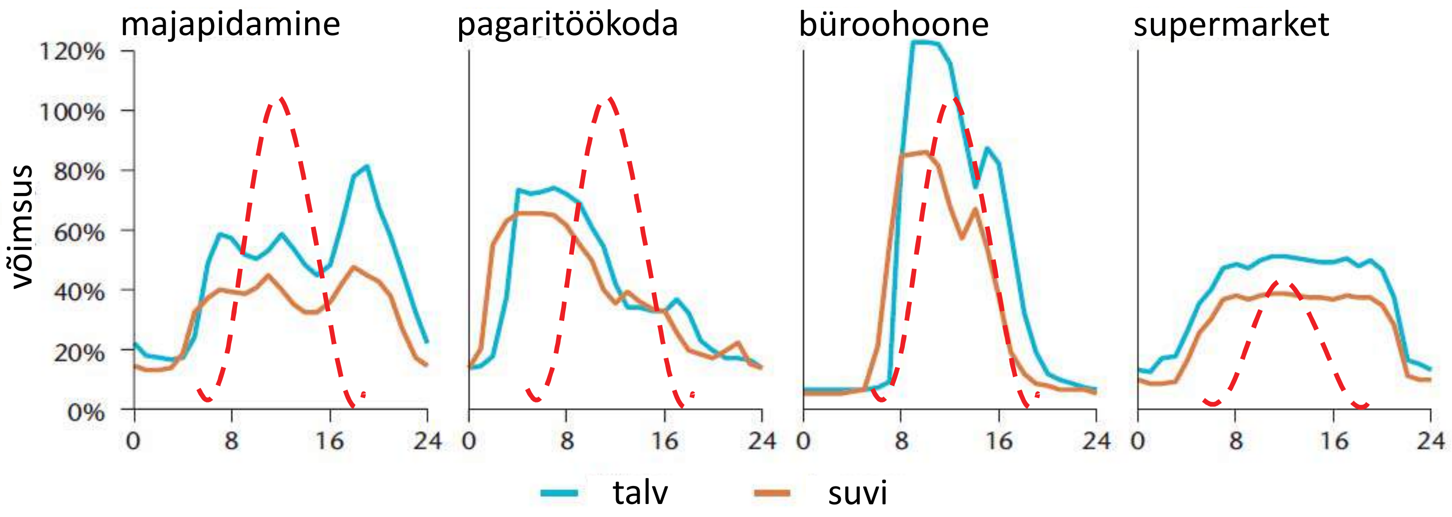
- Pikkus 1km, paneelide pind 2800m2
- Normandias Tourouvre au Perche nimelises külakeses
- Ehitajaks Prantsuse-UK ettevõte Colas
- Elektrit kasutatakse külakese tänavavalgustuse tarvis
- Maksumus 5M €
- Prognoositav toodang 420 MWh aastas (ca. 140 majapidamise aastane elektrivajadus)
- Eesmärk 1km iga 1000km tee kohta päikesetee

Kodumajapidamise tarbimine ja PV



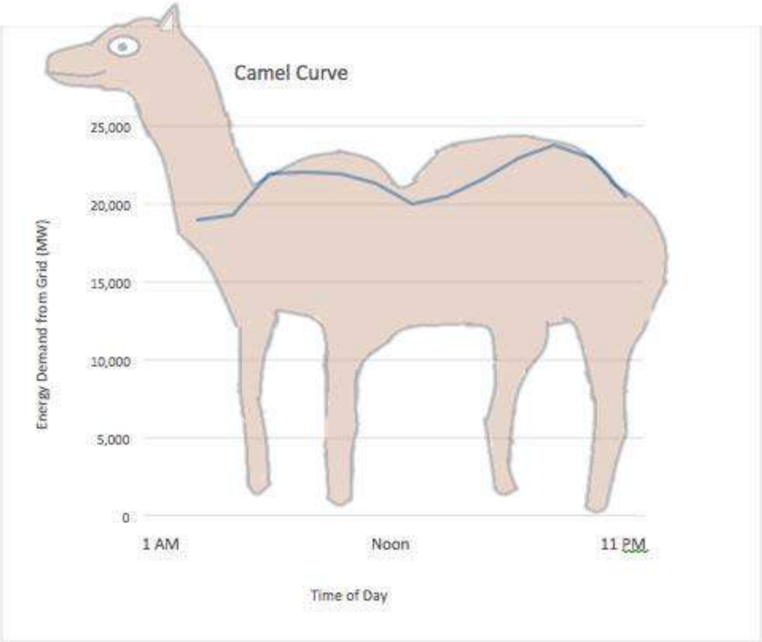
Kes kuidas ja millal elektrit tarbib?

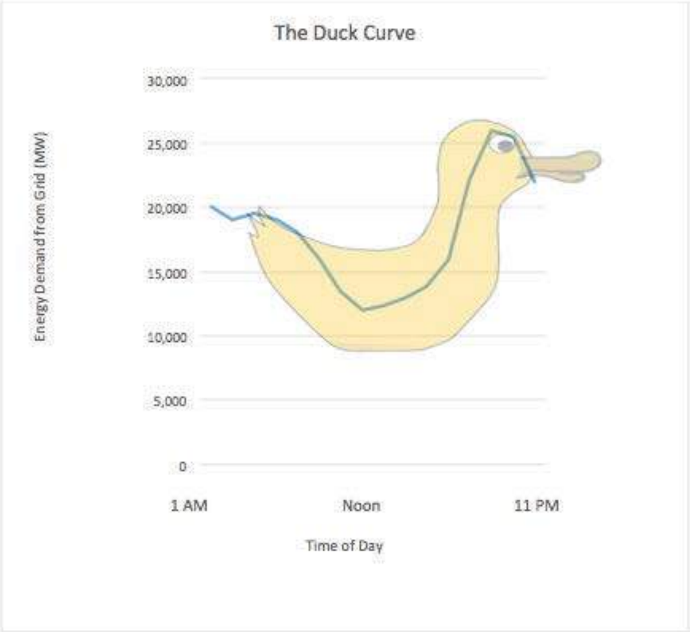
Erinevate tarbijate ööpäevane suvine ja talvine elektritarbimise muster ja päikeseelektrijaama toodang



EPEA

Kaamel ja part





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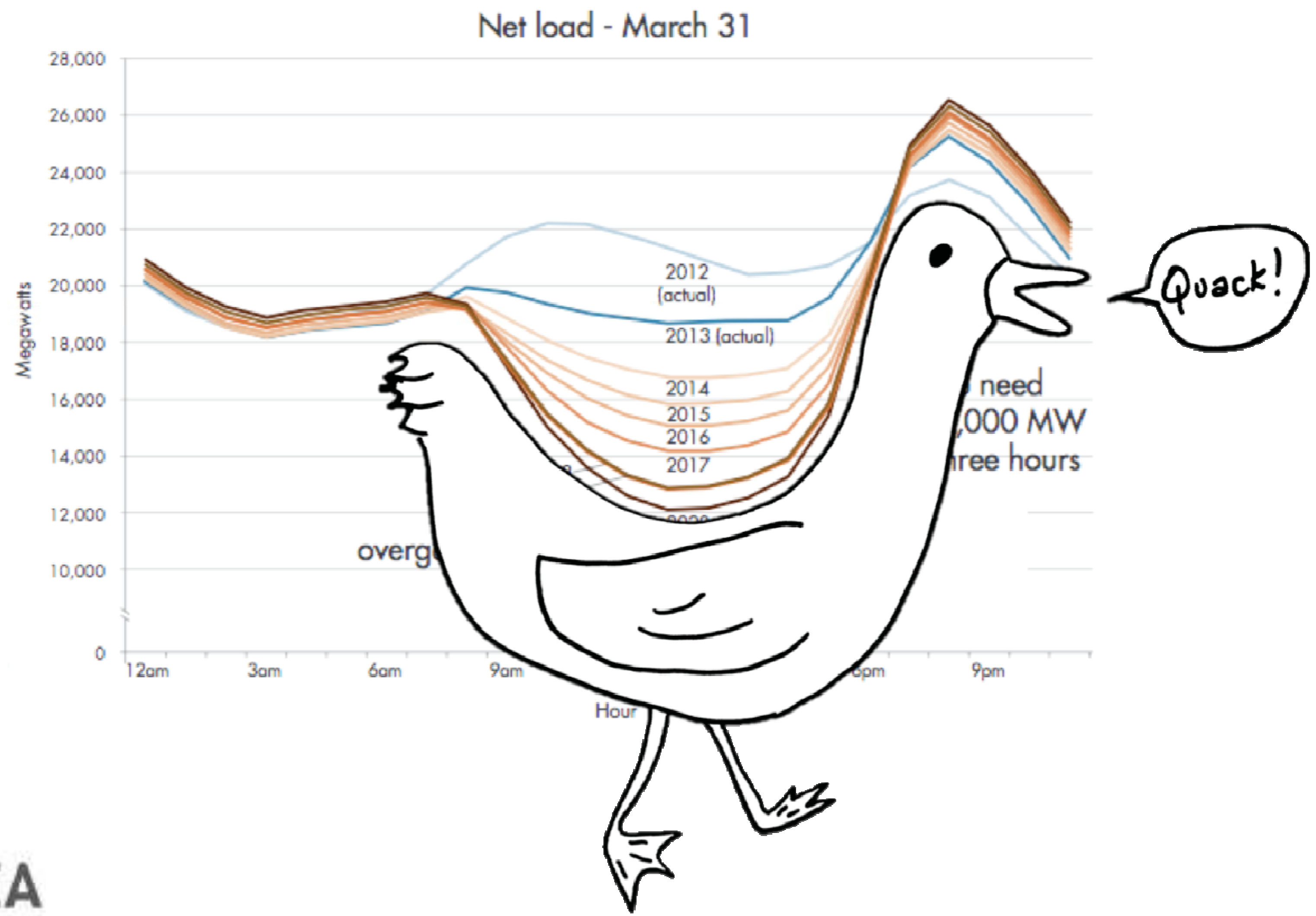
Net load - March 31
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
0
Megawatts
12am
3am
6am
9am
9pm
Hour
2012
(actual)
2013 (actual)
2014
2015
2016
2017
need
,000 MW
ree hours
overg
Quack!

EPEA

Päike ja salvestus käivad kokku nagu või ja leib, nagu suvi ja rand, sukk ja saabas...
Kuluefektiivne salvestus lahendab päikeseenergia kasutamise fundamentaalse probleemi – tootmise ja tarbimise erineva tsükli. Salvestuse abil õnnestub päeva tootmine nihutada katma tarbimistippe õhtul ja hommikul.